VOLUME 3, No. 2 APRIL 1948

CONTENTS

SOIL DEFICIENCIES AND NUTRITIONAL TROUBLES IN ANIMALS
..... Kenneth C. Beeson

PERMANENT COASTAL DUNE STABILIZATION WITH GRASSES AND LEGUMES
..... Robert L. Brown

RESEARCH NEEDS OF TILLAGE IN SOIL AND WATER CONSERVATION
..... G. M. Browning

PLANNING FOR SOUND PRODUCTION CREDIT
..... Laurence F. Whittemore

SOME POLISH SOIL PROBLEMS
..... E. N. Munns

SOIL CONSERVATION WORK IN NURSERIES
..... Joseph A. Abrahamson

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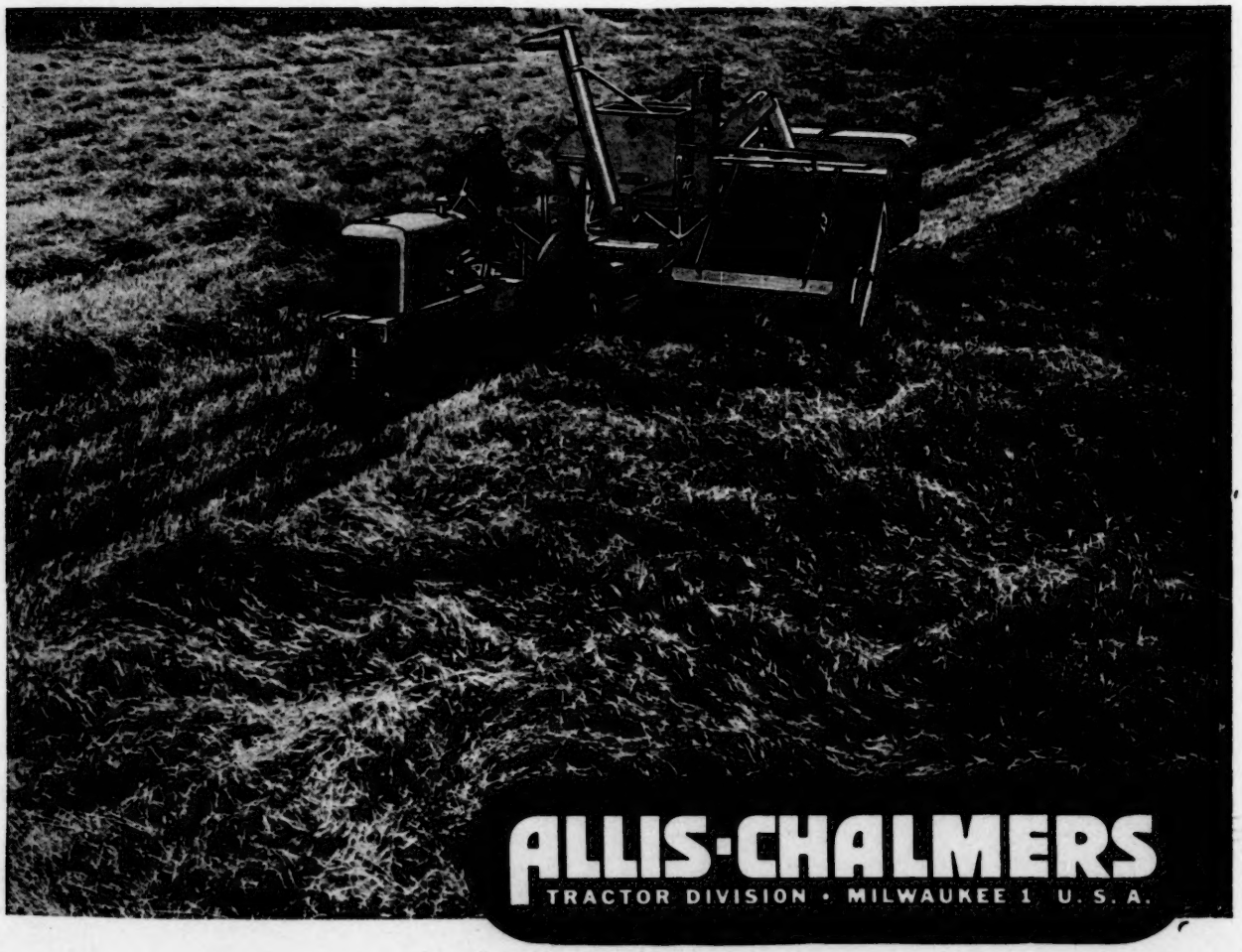

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We Can't Prosper

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To promote this modern farming, the company last fall held the fourth and fifth of a nation-wide series of In-Service Training Courses on farm machinery for Soil Conservation Service personnel. They were staged in Region Five, Lincoln, Nebr., and Region One, Hershey, Pa.

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These men, supported by International Harvester and the IH Dealer in your home town, form an army that is waging a great peace-time battle: the conservation of the land, our greatest heritage. We encourage everyone who daily lives and works with American farmers to assist in the program of soil and water conservation.

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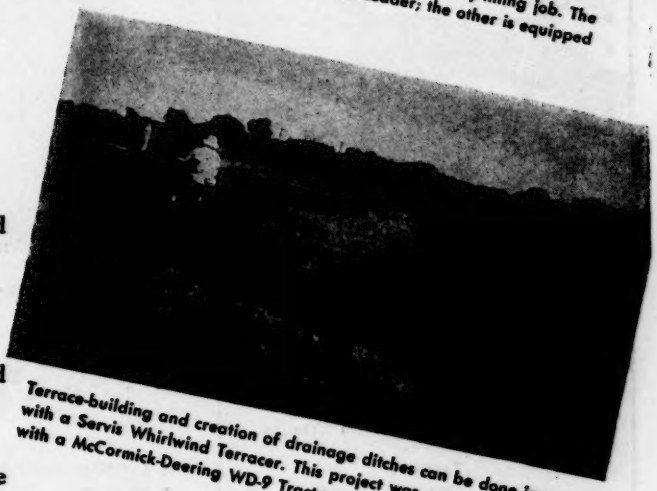
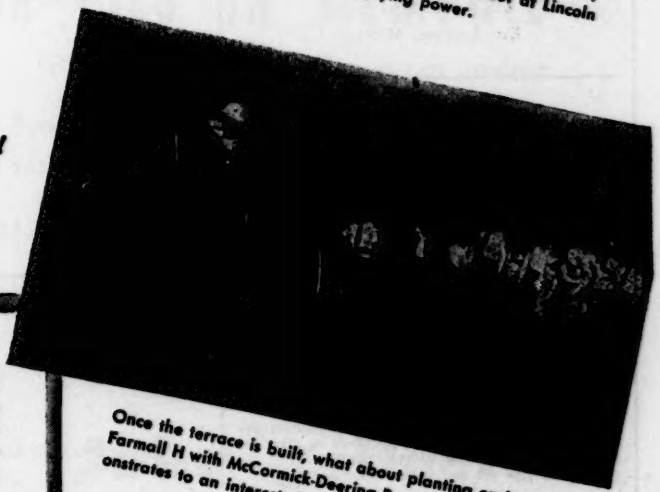
Want to know more about soil conservation? Then write for this FREE booklet titled "Let's Practice Soil Conservation." Address Consumer Relations Dept., International Harvester Company, 180 N. Michigan Avenue, Chicago 1, Illinois.

Two Farmall Diesel Tractors team up at Lincoln on a gully-filling job. The one at left uses a McCormick-Deering Power Loader; the other is equipped with a Servis Bulldozer.



Terrace-building and creation of drainage ditches can be done in a hurry with a Servis Whirlwind Terracer. This project was carried out at Lincoln with a McCormick-Deering WD-9 Tractor supplying power.



Once the terrace is built, what about planting on its side? This Farmall H with McCormick-Deering Beet and Bean Planter demonstrates to an interested group at Hershey just how it's done.

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Contents for April 1948

Editorial 60

Soil Deficiencies and Nutritional Troubles in Animals 61
KENNETH C. BEESON

Permanent Coastal Dune Stabilization with Grasses and Legumes 69
ROBERT L. BROWN

Research Needs of Tillage in Soil and Water Conservation 75
G. M. BROWNING

Pictorial 79

Planning for Sound Production Credit 83
LAURENCE F. WHITTEMORE

Some Polish Soil Problems 85
E. N. MUNNS

Soil Conservation Work in Nurseries 87
JOSEPH A. ABRAHAMSON

Book Reviews 91

Recent Research Reviews 94
JAMES H. STALLINGS

Field Notes and Comments 96

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Unfortunately, you can't feed a hungry world mud pies. That's why we've got to stop soil erosion which feeds a river like the Mississippi, at flood stage, the equivalent of a 40-acre farm every minute. That's why we must enjoy better crop rotations, practice contour farming, and utilize many other conservation methods recommended by agricultural experts if we are to keep our topsoil at home where it can produce the food and fiber so urgently needed.

You who are soil conservationists, county agricultural agents, farmer supervisors of soil districts, or community leaders of similar description are key men in this fight to save the soil. You *are* performing a vital public service. You *are* making our agriculture more secure and, therefore, the future of our Nation more abundant.

John Deere

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EDITORIAL COMMENT

Guest Editorial *by E. H. Taylor*

An actual land policy is now in sight. The act introduced in Congress by Chairman Clifford R. Hope of the House Committee on Agriculture bears the title and meets the full requirements of such a policy. Its passage would be one of the memorable turning points in our history, insuring the foundation of natural resources upon which all national stability rests.

The Hope Act has two decisive merits. It establishes conservation and the orderly development of our land and water resources as a basic policy of the United States. This will focus both public and legislative attention on conservation and will give it a priority it has heretofore lacked.

The act coordinates and unifies all the forces now engaged in a divided struggle to protect and conserve our land and water and their dependent resources. To realize how important such a step is one has only to read this passage in Fairfield Osborn's *"Our Plundered Planet"*: "All the component parts in the machinery of nature are dependent one upon the other. Remove any essential part and the machine breaks down. This is a primary fact and there is no other comparable to it in importance. . . . This interdependence of elements is, in truth, the basic law of nature. Therefore, unless man respects it, nature will not work for him."

Every conservationist has realized this unity of nature. It is brought out by Dr. Ira N. Gabrielson in the recent report of the Iowa Conservation Study Committee, it is voiced in the annual report of Chief Lyle F. Watts of the Forest Service. The men wrestling with flood control in the great watersheds are coming to recognize it. Good land use, soil and water conservation, forestation, flood control, siltation prevention, fish and wildlife propagation are all parts of one proposition. Under the Hope Act we will be able to deal with them as such, coordinating our efforts to correspond with the integrated processes of nature.

The act fairly recognizes and apportions the responsibility for the work among all the various interested agencies. It is especially commendable for the long overdue encouragement it gives to research. And it provides, as it should, for an active and responsible participation by farmers themselves. In fact, its very excellence is a tribute to its author, one of the fairest and ablest men in public life who, by virtue of this act if nothing else, takes rank among the great statesmen of agriculture.

In the Hope Act we have as good and workable a national land policy as we are ever likely to get. It represents the only ultimate answer to the needs of the situation. But it is, as yet, simply a proposal. What it requires is such a groundswell of support that its passage cannot be stayed either by apathy or opposition.

Code of Agricultural Ethics

A good agriculturist recognizes the basic nature of the soil and its relationship to all life and the economy of living. He knows that all individual health, happiness and accomplishment as well as that of community, nation and the world goes back to this indispensable soil.

Recognizing this basic nature of the soil, a good agriculturist will accept the philosophy of stewardship of the land, appreciating that he is holding in trust a parcel of the world's wealth to be used for the good of himself and his fellowman.

The good agriculturist will, therefore, accept the principles of proper land use to protect as well as better the land that he uses.

The good agriculturist will adopt accepted soil practices to protect himself, his neighbor, community and the nation from flood menace and wind-blown soil. He recognizes that all floods have their origin at the place where the water falls and that all dust storms have their origin in the unprotected fields of the farm.

The good agriculturist will shun cash cropping except as it is a temporary loan from the great wealth reserve of our soil, a loan to be repaid with interest.

A good agriculturist will help to seek means which will prevent the unscrupulous from exploiting the wealth of whatever land is temporarily in their hands and see that no land is left as a bankrupt, tax-delinquent public charge.

A good agriculturist will recognize that the science of nutrition is yet in its infancy, but current observations indicate that there is an inseparable relationship between robust, individual and national health and a fertile soil well supplied with humus, organisms, and minerals.

A good agriculturist will, therefore, return to the soil all possible organic material as well as replacing depleted mineral reserves. He will do this by adopting the methods best suited to the conservation of all elements in animal manures and animal and vegetable wastes, and he will refrain from the unwise practice of burning crop

(*Continued on page* 100)

Soil Deficiencies And Nutritional Troubles In Animals

KENNETH C. BEESON

THIS PAPER by Kenneth C. Beeson is most timely because of the widespread interest throughout the world in the relationship of soil and health. Mr. Beeson first presented the paper at the Second Annual meeting of the Soil Conservation Society of America held at Omaha, Nebraska, December 4, 1947. Since then many requests have been received for copies.

Mr. Beeson is Senior Chemist with the United States Department of Agriculture Plant, Soil and Nutrition Laboratory, located at Ithaca, New York. He has been engaged in studies of the relation of soils to human and animal nutrition since 1937.

NUTRITIONAL TROUBLES IN ANIMALS due to abnormal soil conditions have long been known. There are many references to these troubles dating back to the Middle Ages. The observations then made are convincing, and testify to the fact that men were keenly aware that such relationships existed long before they had any knowledge of either soils or nutrition as sciences. Naturally the validity of their explanations as to why a certain trouble occurred can often be questioned. It is necessary for us to acknowledge, however, that with all our modern methods and understanding, we are still committing errors of judgment with respect to these relationships. We still tend to give vent to enthusiastic claims for the enormous possibilities for better nutrition through a simple manipulation of the soil. We have progressed beyond the ancients in that with little thought of the complicated relationships existing, particularly between man and the soil, we interpret our meager data in terms of human as well as animal nutrition.

Relationships Between Soil and Health

The arguments of most enthusiasts who would cure all of our ills by better soil practices generally follow a definite pattern. *First,* the prevalance and distribution of certain diseases are cited with the seriousness of the consequences of these diseases to the human race. The diseases may or may not be nutritional in character. *Secondly,* the accelerated rate at which the fertility of our soils is being destroyed either by overcropping, erosion, or some other cause is stressed. *Thirdly,* these two conditions are brought together to prove the existence of a relationship between soils and health. For example, the following statement was made by one of these writers:

> *"The Japanese have a very high illness and death rate; colds are almost universal at certain seasons. The soils of Japan in large part are mineral-poor."*

Now there is probably nothing wrong with these two statements. The important question is: Are they related? The inference is, of course that they are. Statements of this kind are of the worst sort because an indirect inference is made but no proof is given that the relationship is valid. It takes a lot of effort to counteract the effects of such statements, even though all the scientific facts were available. Furthermore, even though the extreme claims obviously are untenable, it seems clear that when more facts have been discovered through research some generalizations of practical value can be established.

It is well recognized that malnutrition is caused to a much greater extent by a diet which is inadequate in nutritional quality rather than in amount as measured by calories. Nutrition education programs have stressed the use of more of the foods which are the better sources of specific nutrients needed. Furthermore, it has been demonstrated that much can be accomplished through the conservation of nutrients in processing, storing, and cooking. A third general method of diet improvement which particularly deserves consideration in a food and nutrition program is the improvement of the nutritional quality of our basic food supply as produced. It is certain aspects of this which will be discussed in this paper. Space does not permit discussion of certain important influences, such as genetic factors and climatic factors, on the nutritive quality of foods and feeds. Suffice it to say that both of them play a greater part in some cases in influencing the nutritive quality of a plant than does the soil. In all cases the influences of genetics and climate are of importance.

Soil is an Expression of Many Factors

In conducting basic studies of the influence of soil on health, it has been more practical to consider the animal than man himself. The occurrence of nutritional troubles in grazing animals is related to various factors, but certainly one of the most important is expansion into new lands. In the early periods, primitive agriculture was centered around the vast delta areas of Africa and

Asia, the alluvial soil of the Nile and Euphrates flood plains, and in China on the flats of the Yellow River. Here the soil was not dependent upon a fixed parent material, but was a product of an infinite variety of materials washed down by the river from all over a continent and deposited annually to the advantage of the farmer. This continual replenishment was a preventive of deficiency troubles, and it was under such conditions that many animals were first domesticated by man.

As the necessity for new lands arose, man developed new areas. Gradually he was able to select those that through generations of experience he found to be best suited to his need. It is believed, and there is considerable evidence to support the belief (as in Germany, for example) that those soils developed from limestone were certainly among the first, if not the first, to be continuously cultivated. As populations increased, however, we find man always pushing out into new lands, many of which were not at all capable of supporting animal life, particularly when those animals were not permitted to graze large areas and select their food. It was thus soon noticed that there were certain soil characteristics that could be related to certain troubles in animals.

In a broad sense, the soil is an expression of a number of factors—climate, vegetation, rocks, and relief—all acting in the course of time to produce what we have now. There are a great number of possible combinations of these factors, and, consequently, a great number of kinds or types of soil. Speaking generally, variations in rocks, in relief, and in age are responsible for local differences in soil, whereas variations in vegetation and climate are responsible for broad regional differences. For example, should we compare the soils within a county in Tennessee, most of the important differences will be related closely to differences of rock or relief. The same might be said for a similarly small area in New Hampshire. If we contrast the soils of two widely-separated counties, however, it will be seen immediately that their outstanding differences are due to the influence of processes controlled by climate and vegetation.

Nutritional troubles in animals have been associated with both groups of soil-forming factors. Localized troubles seem to be associated most commonly with the rock or other parent material from which the soil was developed. Broad regional areas of nutritional troubles are associated with climatic factors such as rainfall. Naturally the problems involved are not the same in

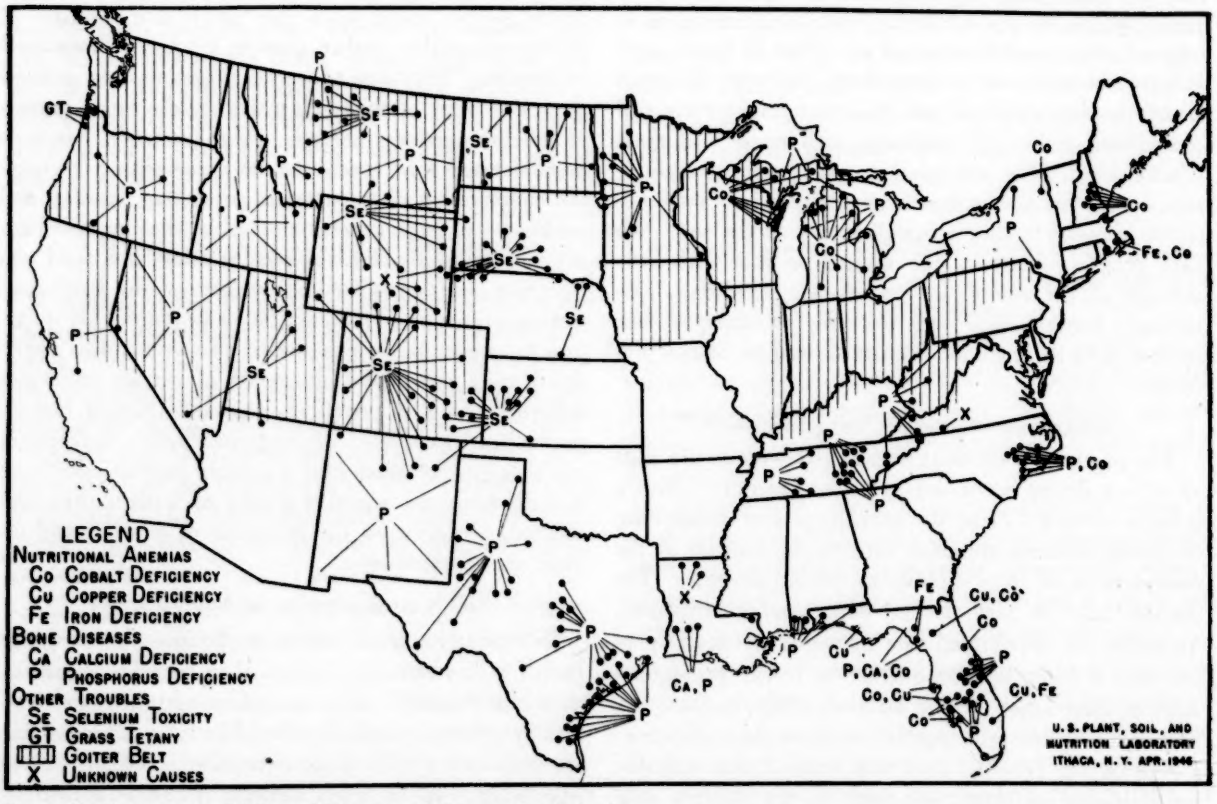

Figure 1. Occurrence of Mineral Nutritional Diseases in Animals.

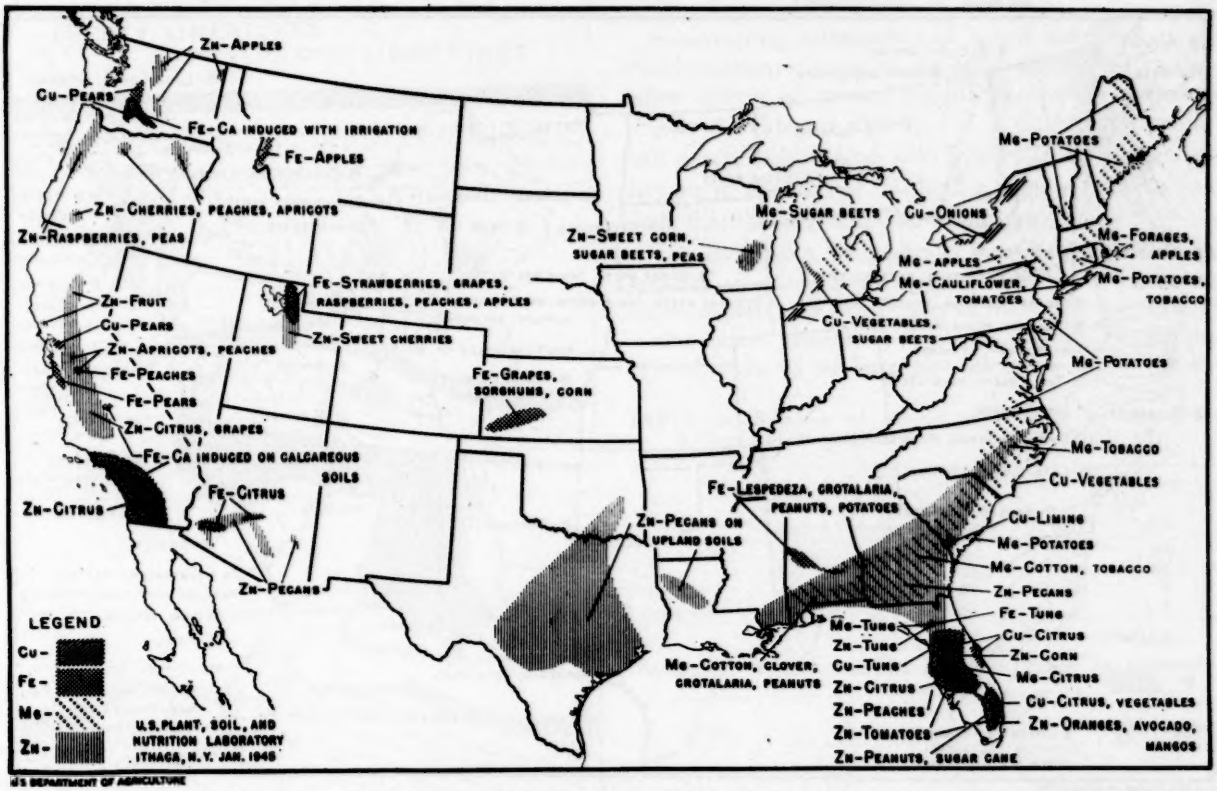

Figure 2. Occurrence of Nutritional Troubles in Plants as Indicated by Responses to Copper, Iron, Magnesium, or Zinc Applications to Soils.

the two kinds of areas, although an element like phosphorus may be deficient under either set of conditions.

Problem Areas are Delineated

At the U. S. Plant, Soil, and Nutrition Laboratory it was felt that the first and possibly the most practical approach to this problem was to locate and map all the known nutritional diseases in both plants and animals. Such information would, we believed, stress our most critical problems and delineate to a reasonable extent the areas involved. Accordingly, reconnaissance surveys were made and maps were prepared (1).

It is clear from the distribution patterns of these troubles (Figures 1 to 3) that they tend to be concentrated along the Coastal Plain areas, the highly-leached and acid soils of the north, and the alkaline soils of the arid west. Each of these areas presents a certain phase of the problem, and the approach to the solution of the problems in any one area is not necessarily applicable to any of the others. In animals, phosphorus deficiency is the most widely known trouble, although goiter is scattered over a wide area of the country. Also, deficiencies of cobalt are now being recognized in many places, and cobalt is rapidly assuming an important place in correcting many troubles that have been difficult to explain.

Phosphorus Deficiency in the U. S.

It is evident that with the exception of iodine, phosphorus is the most widespread of any mineral nutritional trouble in grazing animals. For example, it is believed that the phosphorus content of forage from the virgin soils throughout most of the Atlantic and Gulf Coastal Plains may generally be deficient for herbivora. This becomes apparent, of course, as more and more of these undeveloped lands are utilized for grazing. Likewise there are extensive areas of grazing land in the western part of the country where phosphorus deficiency in animals is common.

Why do these deficiencies exist? If we consider the soil of the United States as a whole (Table 1), we find a rather narrow range of values for their total phosphorus content. Of course, there are extreme variations due to some peculiar characteristic of a parent material. To explain phosphorus deficiencies on regional basis such as in the Coastal Plain regions or in the northwest, we must, however, look for some cause other than a simple deficiency of the element.

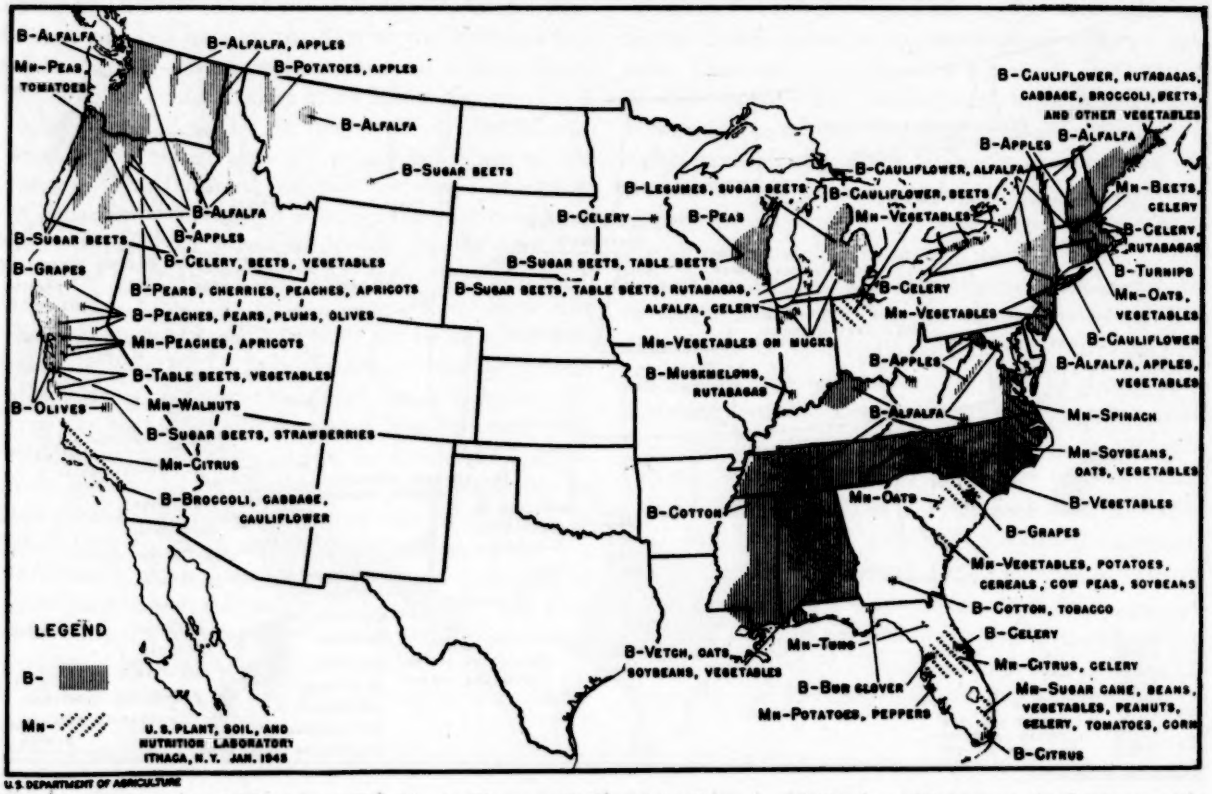

Figure 3. Occurrence of Nutritional Troubles in Plants as Indicated by Responses of Boron or Manganese Applications to the Soil.

One such factor in limiting the availability of soil phosphorus is the reaction value of the soil. In Table 2 the relationship between soil pH and the nature of the phosphorus compounds is presented (2). It is clear that at all levels of pH there will be some limiting factors influencing the amounts of soluble phosphorus, although in general the least trouble is experienced between pH 5.0 and 6.0.

TABLE 1. Phosphorus Content of Surface Horizons of Typical Soils.

Soil Type	Location	Parent Material	Horizon Depth	P_2O_5 %
Caribou loam	Maine	Glacial till	¾ — 2	0.10
Au Train sand	Michigan	Sand	2 — 10	0.01
Miami silt loam	Indiana	Calcareous glacial till	2½ — 9	0.11
Ruston loamy sand	Georgia	Unconsolidated sands & clay	0 — 14	0.07
Cecil sandy clay loam	N. Carolina	Granites, etc.	0 — 6	0.16
Carrington loam	Iowa	Calcareous glacial till	3 — 13	0.10
Barnes loam	S. Dakota	Calcareous glacial till	0 — 9	0.17
Maury silt loam	Tennessee	Phosphatic limestone	0 — 12	0.31
Decatur silt loam	Alabama	Limestone	3 — 6	tr.

TABLE 2. Relation of Phosphorus Compounds in Soil to pH.

pH	Nature of Phosphorus Compounds
2. — 5.	Phosphorus is present as slightly soluble iron and aluminum phosphates
4.5 — 7.5	Phosphorus is fixed on the surface of clay particles
6. — 10.	In the presence of calcium, phosphorus occurs as one more of the basic calcium phosphates

For example, for the Great Plains province of the west and in other parts of the west and southwest, Gardner and Kelley (4) have postulated a series of reactions to illustrate what may occur in the presence of excessive carbonates in the soil:

$$K_2CO_3(\text{excess}) + 9\,Ca(H_2PO_4)_2 + CaCO_3 \rightarrow [Ca_3(PO_4)_2]_3 \cdot CaCO_3 + 12\,K_2PO_4 + 12\,K_2CO_3(\text{excess})$$

$$K_2CO_3(\text{excess}) + 12\,K_2PO_4 + 20\,CaCO_3 \rightarrow K_2CO_3(\text{excess}) + 2\,[Ca_3(PO_4)_2]_3 \cdot CaCO_3$$

Various factors complicate the extent of these reactions, but Ross, Rader, and Beeson (10) have shown that similar reactions do occur where either mono- or di-basic calcium phosphate is mixed with a basic material or with calcium fluoride. The non-availability of these basic phosphates in both soil and fertilizers has been demonstrated by a number of workers.

It has already been suggested that phosphorus is an

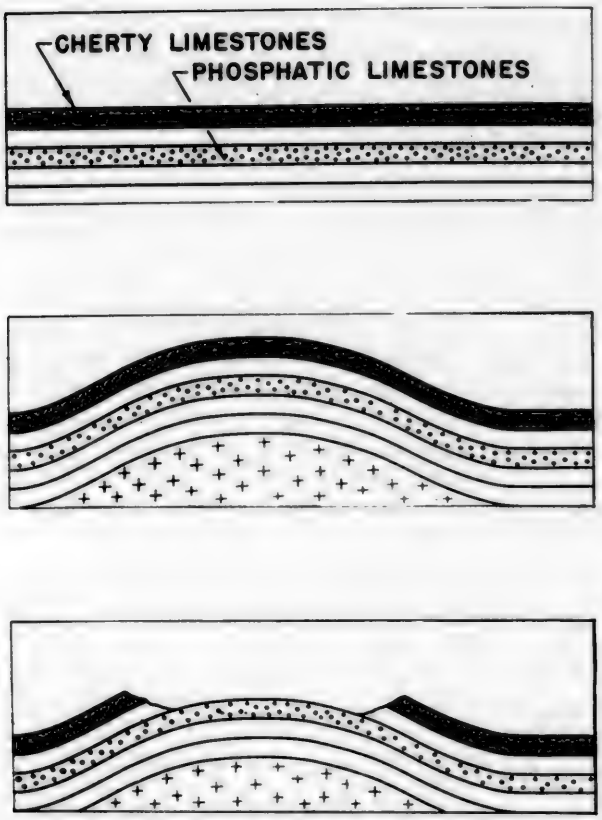

Figure 4. Diagrammatic illustration of the occurrence of a phosphorus-rich soil adjacent to a phosphorus-poor soil.

example of an element that may be limited in quantity both under localized conditions or on a broad regional basis. An excellent example of a localized deficiency of phosphorus is found in Tennessee on a formation known as the "Highland Rim."

This rim is the result of an uplift forming a dome-shaped structure (Figure 4). Repeated peneplanation has reduced the original height. The strong limestones at the crest were eventually eroded to expose weaker materials, and the Nashville basin as we now know it was developed. This process exposed in the present basin an Ordovician limestone bed that was particularly rich in phosphorus. The soil developed thereon, the Maury, is well known as the bluegrass region of Tennessee and Kentucky. With the broadening of the valley, the protecting cherty limestone was undercut, producing an escarpment. The surface above this escarpment is called the "Highland Rim", and the soils developed on it are exceedingly deficient in phosphorus in some cases. Thus we have here a clear example of the effect of parent rock on the phosphorus content of soils, the vegetation, and the health and thriftiness of animals.

Deficiencies of Iodine

A convincing relationship of a soil deficiency to a trouble in man, is found in the relationships between the iodine content of the soil and the occurrence of goiter (Figure 5, Tables 3 and 4). It is clear that there is such a relationship, and when the facts are known as they are in a trouble of this kind it is quite valid to conclude that the relationship is a true one.

The assumption has generally been made that the occurrence of goiter in the northern part of the United States, as well as in other parts of the world, was related to the iodine content of the soil. Within certain restricted areas, as we have just seen, this appears to be

TABLE 3. Relation of Iodine in Food to Incidence of Goiter and to Soil Iodine in New Zealand. (5)

	Goiter incidence	Iodine in soils	Iodine in grass	Iodine in food eggs	Iodine in food milk
	%	p.p.m.	p.p.b.	p.p.b.	p.p.b.
Samoa	Nil	285	326	394	11
Otago	19	64	68	58	8
Canterbury	64	25	67	41	6

TABLE 4. Iodine Content of Some Foods in Germany.

Item	Iodine in goiter-free areas			Iodine in goiter area
	Sprakel	Dreisborn	Hoheleye	Denz
	p.p.b.	p.p.b.	p.p.b.	p.p.b.
Rye, grain	117	133	109	53
Wheat, grain	78	65	—	58
Potatoes	242	182	216	200
Cabbage	240	217	290	88
Onions	225	305	224	117
Lettuce	750	565	670	222
Milk (γ l.)	29.4	63.0	35.0	29.8
Eggs (γ egg)	6.2	—	8.3	2.0

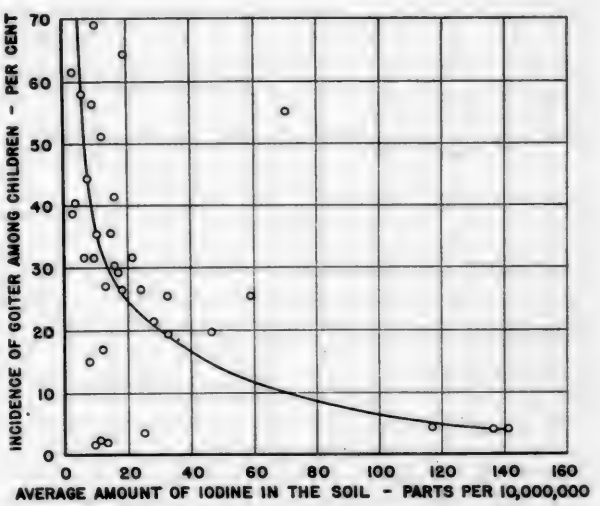

Figure 5. Relation of the iodine content of the soil to the occurrence of goiter in children.

true. Why should the soils over broad regional areas such as our northwest be so low in iodine?

It is well known that iodine does not appear to be deficient in the humid regions, particularly along the coastal areas, although the soils here are highly leached and acid in reaction. There would seem to be little opportunity for iodine to be retained in these soils so as to be readily available to plant roots. On the contrary, iodine-deficient areas of the northwest are associated with a semi-arid climate, and a minimum of soil leaching under alkaline conditions occurs. Very little has been learned about the iodine content of these northwest soils, but the work of Fraps and Fudge (3) in Texas shows that soils in many of the upland semi-arid regions of that state are not greatly different in total iodine than are those from the Gulf Coastal Plain (Table 5).

There is as yet little evidence that will permit classification of rock materials in terms of iodine content. Data from various sources (8, 9) do not indicate any significant differences in the iodine content of sedimentary rock with the possible exception of phosphate rock which has been shown by Hill and Jacob (6) to contain from 10 to 20 times as much iodine as other types of rock. It would appear that the distribution of iodine is of a nature that will require studies of specific areas without recourse to predictions of iodine-content of soils and rocks based on any known occurrence of this element.

Contrary to the popular conception, there seems to be no evidence of any particular relationship of iodine deficiency to the areas subjected to Pleistocene glaciation. It is true that some of these areas are involved, but it is also evident that others of this region are not associated with troubles caused by iodine deficiency. Furthermore, there is no particular reason other than coincidental location to suspect these areas because of glaciation. Although there was a vast mixing action of the rock material over the landscape, no quantity of recognizable material was transported for very great distances. Consequently, the nature of the rock material over the region as a whole should not have differed greatly from the original.

TABLE 5. Iodine in Surface Horizons of Some Soils in Texas. (3)

Origin	No. of Soils	Iodine — p.p.m. Range	Average
Mountains & basins	18	1.6 — 16.2	6.0
High plains	31	0.6 — 14.3	3.9
Rolling plains	50	0.7 — 29.3	7.1
Blackland prairies	61	1.4 — 13.3	5.8
Gulf Coast prairies	51	0.9 — 12.0	3.5
East Texas timber country	66	0.5 — 14.0	2.2

The possibility of rain water as a source of iodine has been suggested by a number of workers. Hercus, Benson, and Carter (5) have calculated that from 22 to 50 mg. of iodine per acre will fall on our Atlantic Coastal Plain as compared to 0.7 mg. in the Great Lakes region. This is undoubtedly an important difference in the source of supply of iodine.

Iodine deficiency, and the occurrence of goiter and associated troubles, therefore, are probably related to several factors, chief among them rainfall (particularly as it affects overall soil composition) and the decomposition of parent rock (with attending influence on iodine availability). Rainfall is also important as a source of iodine in some regions. A secondary factor to rainfall is, no doubt, the texture of the soil and in particular its content of colloids both organic and inorganic. Variation in the composition of parent rock is probably of minor importance, particularly in relation to large regional trouble areas.

The Cobalt Problem

The discovery about ten years ago that cobalt would correct certain troubles of grazing cattle in parts of Australia and New Zealand is now a familiar story. Upon the basis of these observations, it has been found in several parts of the United States, particularly in the Atlantic Coastal Plain and in the northeast that cobalt is deficient in the soils and herbage. As a result, cattle in these regions often exhibit the usual characteristics or symptoms that accompany this trouble.

In the initial soil studies in these regions, the obvious approach, of course, was a determination of the cobalt concentration in the forages. The results confirmed the original diagnosis, since nearly all cases showed the cobalt concentration in the forage to be at a very low level. At first, however, there appeared to be no particular relation to any soil characteristic with the possible exception of texture and drainage conditions. The most obvious factor, parent material, seemed to have little if any relation to the trouble (Figure 7).

For example, suppose that certain soils of granite origin in New Hampshire are compared to soils of similar origin in eastern Maryland. Now, no evidence of cobalt deficiency has been found in Maryland, while it is widespread over the soils of granite as well as other origin in New Hampshire. Obviously a simple factor, parent material (granite in this instance), is not alone responsible for this difference in the health of cattle.

Further research on this problem led to a study of the pattern of cobalt deficiency on the coastal plain region of North Carolina. It became apparent as the investigations progressed that the trouble in this region was related in some way to certain marine terraces. That is, the trouble was never found above certain elevations,

while it did occur frequently on two or three of the terraces of lower levels. The fact that fewer troubles were observed on the youngest terraces is no doubt due to a lack of animals in those areas. Without animals, we have no good indicators of cobalt deficiency.

More intensive work was then undertaken in a specific area of the Coastal Plain where three of these terraces were in conjunction (Figure 6). Of the three terraces represented here, two (the Wicomico and the Penholoway) have been associated with cobalt deficiency in cattle. No troubles of this kind have been observed on the third and highest terrace, the Sunderland.

It was obvious that the relationship here was not to soil type, since the trouble cut across several soil types on the different terraces. For example, the Norfolk sand was involved on both the Penholoway and Wicomico terraces but not on the Sunderland. There probably was some relationship to drainage since the trouble was occasionally more severe on well-drained soils. There appeared to be no discoverable relationship to parent material. This last factor was of less importance on the Coastal Plain, of course, than it would be in areas of the Piedmont.

The one factor, then, that seemed to fit the conditions in this coastal plain area was the age of the soil in terms of total time available for the soil-forming processes to have operated. Just how or why this factor is of importance and to what extent other factors such as leaching have operated to modify the time factor are not clear as yet. Much additional research is necessary in the solution of these problems.

This evidence that time is important is applicable also to the occurrence of cobalt deficiency in New Hampshire and other areas of the northeast. All of these trouble areas are those in which the soils are young and immature. Little time, relatively speaking, has been available for the normal soil-forming processes to have operated. A clearer concept of the relationships of time should aid materially in defining and correcting deficiencies in our soils.

Corrective Measures in Deficiency Areas

In general, these deficiencies are not always directly related to the fertility of the soil in the sense of crop production. This is particularly true of cobalt and iodine. The phosphorus content of vegetation may bear some relation to yield, but it is certainly not a straight-line relationship. What, then, is the most practical and immediate answer to these problems?

Supplementary feeding with the required minerals is the quickest and thus the most effective method, of course. However, there are certain disadvantages in this approach, such as the refusal of an animal to consume

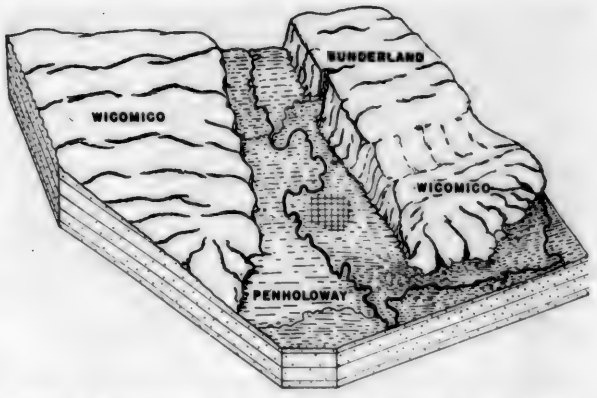

Figure 6. Conjunction of three marine terraces on the Atlantic Coastal Plain. Cobalt deficiency in cattle has been found on the Penholoway and Wicomico terraces but not on the Sunderland. Drawing by R. Siegfried. The elevations are greatly exaggerated.

enough of a mineral nutrient. Fertilization with an element like cobalt could be practical under certain conditions. However, experience has shown that annual applications of cobalt salts often must be applied, for residual effects from one season to the next are small.

Investigations at the U. S. Plant, Soil, and Nutrition Laboratory have demonstrated that different forage species will contain quite different concentrations of elements like phosphorus and cobalt. Bluegrass, for example, may have three times as much cobalt and twice as much phosphorus as will timothy when both are grown under the same set of conditions. Clovers or other legumes (Table 6) often contain two or three times as much cobalt as will grasses growing on the same soil. This suggests, of course, that our recognized pasture and forage improvement programs can be readily adapted to many of our trouble areas. The purpose of our fertilization will be, then, to widen our choice of crops to include those that will benefit the animal through adequate supplies of the mineral elements as well as through higher feeding values.

Biological Assay of Forage Quality

One final question that should be discussed is the effect of fertilization on the quality of a single forage, such as timothy or clover, in terms of animal growth and health. For many years pasture improvement programs have utilized superphosphate and limestone. The use of these materials has resulted in increased yields as well as

TABLE 6. Cobalt Content of Forages from Different Geological Formations.

Forage	Parent rock of soil	
	Limestone	Granite
	Cobalt — p.p.m.	Cobalt — p.p.m.
Red clover	0.37 ± 0.043	0.38 ± 0.019
Timothy	0.12 ± 0.018	0.16 ± 0.042

Figure 7. A case of cobalt deficiency found in the Atlantic Coastal Plain Region.

the introduction of more nutritious forage species in the pasture or forage. The grazing value of land in terms of weight gains of animals or increases in days of grazing have proven the value of this program.

Recently, however, the effect of fertilization on the "overall" nutritive value of a forage has been a matter of interest. This implies an improvement in particular constituents other than the mineral content in the individual forage species, or, more specifically, constituents not ordinarily measureable by laboratory methods.

The general approach to this problem has been to use animal growth as an index of the changes in crop quality. In Table 7, there are presented the results of such a test by Matrone, et al. (7) where sheep were fed soybeans from soils differentially fertilized with respect to superphosphate. It is obvious that there is a tremendous variability as far as animal response to an experiment of this kind is concerned. Although this variability is common to animal experiments, many conclusions about the "hidden effects" of fertilization on plant composition have been drawn without regard to this variability.

Whether or not, in addition to change in their mineral content, there is an "overall" biological improvement in plants as a result of fertilization, it is safe to conclude at the present time that we have no method, biological or otherwise, that will satisfactorily evaluate such an improvement. Unfortunately, many premature conclusions have been made with respect to the effect of fertilizers on the so-called "overall" effects. This sort of experimentation is extremely complex, and must be carried out with great caution, particularly as to interpretations.

TABLE 7. Average Daily Weight Gains of Lambs Fed Soybean Hay and Soybean Meal from Differentially Fertilized Soils. (7)

No phosphate added to soil		200# superphosphate added to soil	
Pen No. (5 lambs each)		Pen No. (5 lambs each)	
1	0.260 lb.	3	0.194 lb.
2	0.120 lb.	5	0.174 lb.
4	0.160 lb.	6	0.109 lb.
Ave.	0.182 lb.	Ave.	0.159 lb.

Summary

This presentation represents a very general picture of the problems involved in studies relating soils to nutritional troubles in animals. At the U. S. Plant, Soil, and Nutrition Laboratory, the approach has been in two stages: first, the problem areas were outlined and classified, and secondly, the management practices desirable in these areas in order to correct the deficiencies are being determined.

The progress already made in this general field of crop production makes it clear that the problems are of sufficient importance, and the results to date sufficiently promising, to justify research programs of the magnitude and character which are essential to explore fully the possibilities involved. There is a great need for controlled experiments which recognize the complexity of the soil as a physical and biological system, those factors which are concerned in plant growth, and the constituents of food crops which are significant in determining their nutritive value. Integrated studies by soil, plant, and nutrition scientists are called for to provide data which can be translated into reliable and practicable field procedures. Quick results are not to be expected. It took many decades to develop the present knowledge as to how to control cultural factors in the interest of maximum yield and desirable market qualities. No one can predict how important and how practical the final results will prove to be. Like all other research, the answers can come only when the facts are known.

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(*Continued on page* 100)

Permanent Coastal Dune Stabilization With Grasses And Legumes

ROBERT L. BROWN

COASTAL SAND DUNES have long been a problem in many sections of the country. This paper by Robert L. Brown outlines a permanent method of stabilization through the use of grasses and legumes.

Mr. Brown is Assistant Chief, Regional Nursery Division, Soil Conservation Service, Portland, Oregon. He expresses appreciation to B. R. Lausch and E. L. Guenther for assisting in obtaining field data and in interpreting it; to Dr. A. L. Hafenrichter for assisting in planning the trials, giving constructive criticism throughout the trial period, and in analyzing data and reviewing this manuscript; to C. A. Loe for assisting in planning the trials and making land available for the seedings.

SAND DUNES ARE BEAUTIFUL. They attract thousands of vacationers. However, their beauty seldom awes the one whose farm or home they are burying. From the Straits of Juan de Fuca to Baja California 90,000 acres of migrating sand dunes are a problem. They require permanent stabilization for the protection of agricultural lands and other properties. Initial stabilization of active dunes is accomplished by planting clones of beachgrass. However, beachgrasses do not provide permanent vegetation because they die out when the sand is stilled. Permanent stabilization requires the planting of perennial species after initial control has been accomplished.

In the literature on dune control repeated reference is made to the use of shrubs and trees for permanent stabilization. McLaughlin and Brown (1) used native grasses and legumes for permanent control, making two different seedings. No reference has been found where commercial species have been used or where permanent control has been achieved by a single seeding into the beachgrass plantings.

Dune stabilization is expensive. The work would be facilitated if complete control could be achieved by these two steps in two or three years after the work is begun. The following studies were made with this objective in mind.

Materials and Methods

A typical area of dune sand initially stabilized with a planting of European beachgrass, *Ammophila arenaria*, Figure 1, was selected for these trials.

The grasses and legumes that were used in these field trials had given excellent results in observational tests. Species and rates of seeding per acre, based on 100 percent live-pure seed, were:

tall fescue *Festuca elatior* v. *arundinacea*	10 pounds
Clatsop red fescue *Festuca rubra*	6 "
common ryegrass *Lolium multiflorum*	4 "
seashore bluegrass *Poa macrantha*	5 "
hairy vetch *Vicia villosa*	10, 20, 25, 30, 40 "
seaside lupine *Lupinus littoralis*	6 "
purple beachpea *Lathyrus maritimus*	20 "
birdsfoot trefoil *Lotus corniculatus*	4 "
red clover *Trifolium pratense*	5 "
crimson clover *Trifolium incarnatum*	10 "

Tall and Clatsop red fescues and common ryegrass were the grass base for most mixtures. To this base each legume was added separately to form mixtures. In another set of mixtures these grasses plus hairy vetch at 25 pounds formed the basic mixture to which all other legumes were added singly to form two-legume mixtures. Seashore bluegrass, Clatsop red fescue, purple beachpea and seaside lupine were used in one mixture made up entirely of native species. All legumes were treated with the correct bacterial inoculant at time of seeding.

The field was divided into plots each 24 feet by 330 feet in size. Six foot borders were left between plots and a sixty-foot border enclosed the entire plot area. Plots were randomized and replicated three times.

Seeding was done with a double disk, fluted-feed grain drill with small-seed attachment. The rate of feed was calibrated for each mixture or single species seeded. Depth of seeding was one and one-half inches except for crimson and red clovers and birdsfoot trefoil. These were broadcast on the surface by pulling the drill spouts. Seeding was done between October 17 and November 10.

Fertilizer (16-20-0) was applied at 150- and 300-pound per acre rates. Appropriate checks were left. Application of the fertilizer was made ten days after seeding. Yield and plant composition were determined by the quadrat method at the end of each growing season. Yield was determined by taking three mil-acre samples and plant composition from three quarter mil-acre quadrats per plot. All weights are given on an air-dry (12 percent moisture) basis. Hand separations were made to show the material resulting from the permanent seeding and that from the initial planting. Composition counts show number of square decimeters per one-quarter mil-acre that contain the species.

A section of the initially stabilized dune was left unseeded and unfertilized as a check against techniques of these trials.

Results

The effect of legumes on the establishment and persistence of plants in a mixture seeded for permanent dune control is shown in Table 1. Grasses seeded in a mixture with hairy vetch established at a very high rate and by the end of the second growing season had the highest stand density and vigor of all mixtures seeded. Grasses established in a mixture with seaside lupine had the greatest density of stand at the end of the establishment year, but declined during the second season. A mixture containing both hairy vetch and seaside lupine had a high rate of establishment and stand density was maintained. Grasses sown in mixture with purple beachpea had a rate of establishment equal to that given with the other two legumes. The second year stand is lower than with either lupine or vetch. Grass stands established by using a combination of hairy vetch and purple beachpea were lower than with either the vetch alone or with vetch and lupine. Stands of tall fescue are established without difficulty by use of any one of the three legumes, but not when legumes are omitted from the mixture. Clatsop red fescue, found in the climax herbaceous cover of these dunes, established best when provided with the shade and the protection from sand scour afforded by hairy vetch.

The more slowly developing native, perennial legumes do not offer such good protection as the hairy vetch. This is shown in Table 2 which summarizes the yield of air-dry material harvested from the plots. The weights given in the table are for seven separate mixtures. Total weight is broken down into two fractions. The beachgrass fraction is composed of the material resulting from the initial planting. The seeded species fraction is the result of seedings made for permanent stabilization. The amount and percentage of beachgrass varied widely for the different mixtures. The weight of 11,162 pounds shown for the seeding with no legume was the highest produced. The seeded species portion varied from 6,172 pounds in a simple vetch mixture to 234 pounds when no legume was included. Slow-growing perennial legumes in a seeding produced intermediate quantities.

Mixtures varied in composition. This depended upon the legume present. Purple beachpea gave a high percentage in favor of the seeded species as did all mixtures with vetch. Seaside lupine and the other native species produced vegetation more equally divided between the

Figure 1.—A typical area of coastal dune sand initially stabilized by a planting of European beachgrass. This site is ready for seeding to a mixture of grasses and legumes for permanent dune stabilization.

TABLE 1. Effect of legumes on the establishment and persistence of plants in a mixture seeded for permanent dune control, as shown by average plant count per one-quarter mil-acre at end of first and second growing seasons. All mixtures given a 300 pound per acre application of fertilizer (16-20-0) at time of seeding.

	LEGUME SEEDED WITH GRASSES IN MIXTURE										CHECK			
	Hairy Vetch 25#		Seaside Lupine 6#		Purple Beachpea 20#		Hairy Vetch 25# Seaside Lupine 6#		Hairy Vetch 25# Purple Beachpea 20#		Native Species		No Legume	
Species	1st yr.	2nd yr.	1st yr.	2nd yr.	1st yr.	2nd yr.	1st yr.	2nd yr.	1st yr.	2nd yr.	1st yr.	2nd yr.	1st yr.	2nd yr.
Tall fescue	78	74	82	42	65	26	62	49	53	49	....	....	19	22
Clatsop red fescue	75	89	91	1	76	19	85	45	53	6	28	58	43	32
Common ryegrass	4	37	0	0	45	1	0	1	0	4	....	....	14	1
Seashore bluegrass	....	....	....	....	....	....	....	....	....	....	8	21	....	....
European beachgrass	8	22	17	44	8	9	12	27	15	23	4	11	40	35
Seaside lupine	....	....	4	16	....	....	28	42	....	....	38	22	....	....
Purple beachpea	....	....	....	....	3	8	....	....	24	35	10	7	....	....
Hairy Vetch	15	16	....	....	....	....	9	0	6	0	....	....	....	....
Perennial invaders	0	26	0	89	0	35	0	60	0	53	0	20	0	22

TABLE 2. Effect of legumes on the quantity of erosion-resisting mulch and ground cover provided by a mixture seeded for permanent dune control. Quantities shown in pounds of air-dry vegetative material harvested per acre at end of second year. All mixtures were given a 300 pound per acre application of fertilizer (16-20-0) at time of seeding.

	LEGUME SEEDED WITH GRASSES IN MIXTURE					CHECK	
Mixture Fraction	Hairy Vetch 25#	Seaside Lupine 6#	Purple Beachpea 20#	Hairy Vetch 25# Seaside Lupine 6#	Hairy Vetch 25# Purple Beachpea 20#	Native Species	No Legume
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Beachgrass	1,531	4,141	594	2,250	1,219	1,960	11,162
Seeded species	6,172	3,828	3,296	4,703	3,781	1,830	234
Total	7,703	7,969	3,890	6,953	5,000	3,790	11.396

two fractions. The mixture containing no legume produced material made up almost entirely of the beachgrass from the planting made for initial stabilization.

Fertilizer application had a definite effect on the amount of vegetative material produced by planted permanent control species. This is shown in Table 3. Highest rates of application gave the greatest yields. There was a direct relationship between production and rate of application for the mixture containing no legume. This relationship was masked in the grass-legume mixtures. There was little difference in yield between no fertilizer and 150 pounds per acre of 16-20-0. There was a great increase when 300 pounds was applied.

The effect of rate of seeding hairy vetch in a grass-legume mixture for permanent coastal dune control on the composition of the resulting stand is shown in Table 4. The plant counts indicate that the total number of plants in the established stands did not vary greatly, regardless of rate of seeding the hairy vetch. Clatsop red fescue increased with age of stand in all plots. Rate of seeding the hairy vetch had no effect on the rate of increase. The average rate of increase for the Clatsop red fescue was 31 percent during the second year. Common ryegrass did not persist in the mixtures. Hairy vetch was still producing in the sixth year from volunteer plants. Tall fescue is decreasing in plant count in every mixture. Invading perennials are found in largest numbers when Clatsop red fescue is present in lowest amounts regardless of the total stand composition.

The total yield of erosion-resisting vegetation resulting from different hairy vetch rates of seeding is shown in Table 5. The twenty-pound rate of seeding gave the lowest total vegetation yield and also the lowest yield of material from seeded species. Ten, thirty, and forty pound rates did not vary greatly in total production. The material from seeded species did vary greatly between rates of seeding.

Crimson clover, red clover, and birdsfoot trefoil failed to establish and persist in quantities greater than a trace, regardless of the treatment given. Results with these species are not shown in summary form.

A check plot for the entire field trial produced only 974 pounds of erosion-resistant ground cover. Sixty-nine percent of the area was not protected by this scant cover. No fertilizer applications were made on this plot. A comparison between the protection afforded the dune sand by the cover on this check plot and that produced

TABLE 3. Effect of different rates of fertilizer (16-20-0) application at time of seeding on the quantity of erosion-resisting mulch and ground cover provided by mixtures seeded for permanent dune control. Quantities shown in pounds of air-dry vegetative material harvested per acre at end of second year.

Quantity of Fertilizer applied	Quantity of Air-dry Vegetative Material Harvested /		
	Average of all Mixtures	Average Vetch-Pea-Lupine Mixtures	Check (No Legume)
300	5,935	6,305	9,499
150	2,724	2,243	5,187
0	2,043	2,234	2,054

TABLE 4. Effect of rate of seeding hairy vetch, *Vicia villosa*, on the establishment and persistence of plants in a mixture seeded for permanent dune control as shown by average plant count per one-quarter mil-acre at end of first and second growing seasons. All mixtures given a 300 pound application of fertilizer (16-20-0) at time of seeding.

Species	Hairy Vetch Rate of Seeding in Pounds per Acre							
	Ten		Twenty		Thirty		Forty	
	1st yr.	2nd yr.	1st yr.	2nd yr.	1st yr.	2nd yr.	1st yr.	2nd yr.
Tall fescue	68	29	40	34	61	45	71	37
Clatsop red fescue	23	28	26	39	44	55	23	30
Common ryegrass	7	1	18	0	25	1	2	1
Hairy Vetch	10	3	15	6	6	16	2	10
Perennial invaders	0	99	0	33	0	45	0	71

by a mixture seeded into this type of cover for permanent dune stabilization is shown in Figure 2.

Discussion of Results

The attempt to find commonly available, rapid-developing legume and grass species or strains for permanent coastal dune control seedings was successful. Hairy vetch, in all of the mixtures, was established easily. It produced abundant protective cover for slowly developing species. This vetch persisted until the more permanent species became established. Hairy vetch cannot be considered as the permanent legume in the mixture. It is an annual which must volunteer to maintain a stand. Competition and poor seed-developing conditions on the dune areas preclude these possibilties.

The rate of seeding hairy vetch in a mixture is not too important, based on results from these trials. The twenty-pound rate for undertermined reasons failed to yield as well as the ten-pound rate. Ocular determinations during the establishment year indicated that a ten-pound rate of seeding was light. Thirty and forty-pound rates gave protective covering sooner than the light rate. The thirty-pound rate of seeding hairy vetch is recommended.

The two legumes native on the dunes were compared with hairy vetch as legumes for permanent dune-control seedings. These species are both perennial. The seaside lupine is a short-lived species. Purple beachpea is a long-lived plant. It persists on permanently sodded dunes in the areas where it is native. From yield determinations, the lupine establishes itself more rapidly than the beachpea, but not as rapidly as the hairy vetch. Seedlings of the lupine are well-developed in the second year whereas the beachpea reaches maximum development in the third and fourth years. It offers no ground protection during the establishment year. This slow development of the perennial legumes has also been the greatest cause for the decline of the permanent grass stand during the winter of the second year. They provided no mulch for the protection of the grass seedlings against the sand movement and its abrasive action. Hairy vetch provided this protection.

Seedings from mixtures containing both hairy vetch and one of the perennial legumes were successful. Grasses became established and thrived. The combination of vetch and lupine produced a greater volume of vegetation during the first and second years than a mixture of vetch and beachpea. This is because lupine is more rapid-developing than the beachpea. The vetch-beachpea combination gave satisfactory results during the two years. Based on these results and determinations from the permanent native vegetation on the dunes, hairy vetch and purple beachpea should be combined as the legumes for a permanent dune stabilization mixture. The hairy vetch will persist at least until the beachpea is well developed; then its presence is no longer essential.

Crimson clover, red clover, and birdsfoot trefoil failed to demonstrate their adaptability for permanent dune control seedings. Crimson clover emerged and was evident in a fair stand during the spring of the first year. It failed to set seed, and, since it is an annual, failed to perpetuate itself. Red clover and birdsfoot trefoil became established only in extremely thin stands on the more favorable sites. Scant vegetative cover and dry surface sand make it difficult for small-seeded species to become established unless they can be seeded deeply.

Grasses and Legumes Provide Permanent Cover

Legumes alone would not give permanent dune control. Grasses grown in combination with the best legumes do provide this permanent cover.

Common ryegrass does not persist in the permanent seedings. Native species were slow to develop and were costly. Hairy vetch can replace seaside lupine and common ryegrass can replace seashore bluegrass. Common ryegrass develops more rapidly and gives protective cover

TABLE 5. Effect of rate of seeding hairy vetch, *Vicia villosa*, on the quantity of erosion-resisting mulch and ground cover provided by a mixture seeded for permanent dune control. Quantities shown in pounds of air-dry vegetative material harvested per acre at end of second year. All mixtures were given a 300 pound application of fertilizer (16-20-0) at time of seeding.

Mixture Fraction	Hairy Vetch Rate of Seeding in Pounds per Acre			
	Ten lbs.	Twenty lbs.	Thirty lbs.	Forty lbs.
Beachgrass	832	1,000	1,469	1,177
Seeded Species	4,168	2,872	3,390	4,043
Total	5,004	3,872	4,859	5,251

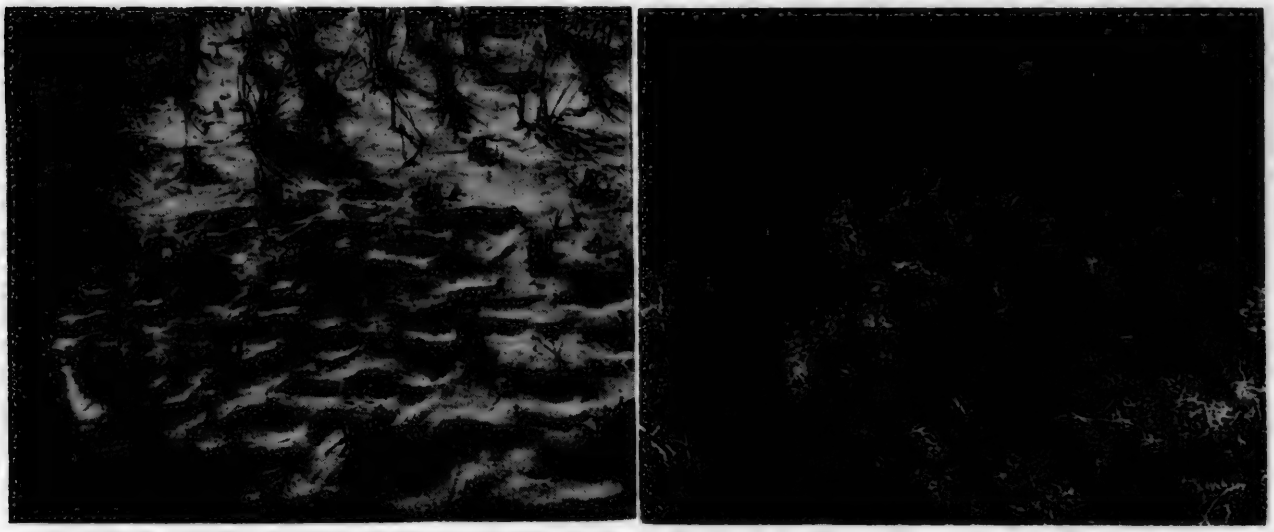

Figure 2.—Permanent coastal dune stabilization is possible in two steps. Left—initial sand-stilling by planting beachgrass and right—permanent stabilization by seeding a mixture of adapted grasses and legumes. The first step does not provide permanent stabilization. The second step cannot be accomplished until the first has been established. An application of fertilizer at seeding time assures successful establishment.

against sand scour during the first winter and spring after seeding. This is when protection is vitally needed. Its place in the stand is then assumed by the slower developing tall and Clatsop red fescues as they develop.

Tall fescue, a commonly available perennial, established easily in all mixtures where hairy vetch was seeded. It developed rapidly and provided excellent erosion-control cover after the first winter. Data indicate this species may not be as permanent as the native Clatsop red fescue which is the main species in the permanent cover of these dunes.

The Clatsop red fescue used in the mixtures of these trials is a selection made from the native dune vegetation. It produces a vigorous seedling and establishes readily if the sand is stilled. It was used in these trials because in previous tests it had outperformed all commercially available and other native strains. The Clatsop strain recovers earlier in the spring and matures later than any other strains tested. It recovers after clipping, more rapidly than either commercial or other native strains and also produces more winter cover. Yields of both seed and vegetal growth surpass those of other strains. It is especially well-adapted for permanent dune-control seedings as it is green throughout much of the summer and winter when other strains and species are brown and dormant. The summer-green habit of this strain is especially beneficial in cutting down fire hazards on the dune area. These hazards are always present when summer dormant species are used. It is not a vigorous sod-former and does not become sod-bound. In spite of this feature it produces a greater erosion-resisting ground cover than other strains because of its abundant, long leaf blades which form a mulch on the ground.

The all-native species mixtures originally used for permanent stabilization of the coastal dunes was not entirely effective. This was because of the slow development of the perennial legume. The other disadvantage was the lack of needed seed. Seed was available from the native stands only in a few areas along the coast. Collection was costly and uncertain.

The severity of the site to be seeded usually has required two separate seeding operations after the initial planting of beachgrass to obtain permanent stabilization with these native species. First, the more tolerant, rapid developing, and short-lived seashore bluegrass and seaside lupine were seeded. Then one or two years later, after protective ground cover had been established, the purple beachpea and red fescue were seeded. Lack of seed left many areas not permanently stabilized. This can be overcome by the use of newly tested species and strains.

The invading perennials shown in Tables 1 and 3 are native species well-adapted to permanent dune control. Their inclusion in a mixture is not justified. Seed is not available commercially and local collection has been prohibitive in cost. Each plant in this group is a valuable addition to the resulting dune cover.

The definite response of all mixtures to fertilizer application at time of seeding conforms to results obtained

on initial beachgrass plantings and reported by McLaughlin and Brown. (1) This response to the highest rate of application is shown by yield data in Table 3. The response is influenced by the low fertility level of the soil type. Low rates of application are not sufficient to bring the fertility level of the soil up to the point where plants can take full advantage of the nutrients. The performance of the mixture, Table 2, that included no legume gives the best portrayal of the direct benefits derived from the different rates. The beachgrass plants were already established and could immediately absorb any nutrients made available. There was some delay in this action with newly seeded species.

Results with fertilizers demonstrate the need for applications of at least 300 pounds per acre of 16-20-0 at time of seeding or shortly after. Fertilizer applied to both initial and permanent dune control plantings have assured successful plantings. Permanent stabilization can be attained from plantings without fertilizer only with continued, costly maintenance and long periods between steps in control.

Conclusions

The use of hairy vetch in a seed mixture can eliminate the necessity for the second seeding operation to obtain a permanent cover. It will cut to two the number of steps necessary to progress from denuded dunes to permanent stabilization.

A recommended mixture for this permanent seeding is:

Species	*Seeding rate (pounds per acre)*
tall fescue	10
Clatsop red fescue	6
common ryegrass	4
hairy vetch	30
purple beachpea	20

The use of fertilizer (16-20-0) at 300 pounds per acre on newly seeded permanent mixtures for dune stabilization will reduce the period of transition from denuded sand to permanent stabilization to two years instead of the five or more that have been common.

Summary

Initial sand-stilling plantings of beachgrass are not sufficient to permanently stabilize eroding coastal sand dunes. Seedings of perennial grasses and legumes must be made to provide a close permanent vegetative cover over the loose, moving sand.

Seedings of grasses and legumes can be made for permanent dune stabilization into one-year-old plantings of beachgrass if they are vigorous and have stilled the sand. Mixtures of commonly available grasses and legumes were better than native grasses and legumes for permanent dune stabilization. The most satisfactory mixture contained hairy vetch, common ryegrass, purple beachpea, Clatsop red fescue, and tall fescue.

The hairy vetch and the common ryegrass are rapid-developing but short-lived species that serve as companion crops until the slower developing and long-lived species become established. The vetch provides nitrogen and litter. The vetch and the ryegrass also provide shade and surface protection.

Studies on the rate of seeding hairy vetch indicated it should be planted at 30 pounds per acre.

The purple beachpea is a slow-developing but long-lived perennial that becomes the permanent legume in the mixture. Clatsop red fescue and tall fescue become the permanent grasses in the mixture. The Clatsop strain of creeping red fescue was developed especially for this use. Its characteristics are described.

On the low-fertility level beach dunes, 300 pounds of fertilizer (16-20-0) per acre should be applied to the secondary seedings when they are planted. At 150 pounds per acre results were not satisfactory.

Other legumes tested were not as satisfactory as beachpea for permanent stabilization. Crimson clover, red clover, and birdsfoot trefoil did not become established even when fertilized.

LITERATURE CITED

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Alas for Human Culture!

The civilized nations—Greece, Rome, England—have been sustained by the primitive forests which anciently rotted where they stand. They survive as long as the soil is not exhausted. Alas for human culture! Little is to be expected of a nation, when the vegetable mould is exhausted, and it is compelled to make manure of the bones of its fathers. There the poet sustains himself merely by his own superfluous fat, and the philosopher comes down on his marrowbones.

—HENRY DAVID THOREAU

Research Needs Of Tillage In Soil And Water Conservation

G. M. BROWNING

GEORGE M. BROWNING has long been interested in the problem of soil structure and tillage as it relates to crop production and soil and water conservation. His paper, based on research needs of tillage, was presented at the Second Annual meeting of the Soil Conservation Society of America at Omaha, Nebraska, last December.

Mr. Browning holds a joint appointment between the Research Division of the Soil Conservation Service and the Iowa Experiment Station, with headquarters at Ames, Iowa.

FARMERS SPEND MORE TIME and money on tillage and know less about it than any other farm operation. Why is this? It is because they have such widely different ideas of the requirements of a good seedbed. The aim is a seedbed that favors high yields of crops. This means the soil must have favorable air, water and nutrient relationship. But what is this for different crops and climatic conditions? There are many ideas, but actually we don't know. I believe that we shall not get the seedbed desired until we really understand the effects of soil structure on plant growth. How can we expect to build a tillage implement to help develop and maintain good soil structure unless we know exactly what is needed? As I visualize it, a good seedbed for our major crops has some of these characteristics: *It is one from which the fine grain-like granules or aggregates trickle through your fingers when you pick up a handful of soil. It feels loose and mellow in your hand. It is well supplied with readily available organic matter. It contains enough large pores to allow rapid moisture movement into it during periods of heavy rainfall or allows rapid movement of water into drain tiles. It contains enough air so that the millions of soil microorganisms are actively decomposing an abundant supply of readily available organic matter, liberating nutrient materials for the plant. Its granules and aggregates are in small clumps and not in large clods. The granules are stable and resist the beating action of rain drops. It is loose and mellow but not too loose for good germination of the seed. It also has favorable air, water and nutrient relationships at a depth favorable for root development.*

Now to get at the core of this problem let us briefly review some of the research in progress and then consider additional research needed to determine how to develop and maintain soil structure favorable for high crop yields and soil and water conservation.

Soil structure is not the result of any one factor. It is a combination of factors operating through many years in the development of the soil. It is more directly affected by the soil management practices since the land has been under cultivation. It is also influenced by the type and amount of rainfall, the amount of erosion, freezing and thawing and tillage practices.

The Soil

It is well recognized that soils have widely different physical and chemical characteristics. A sandy soil has a different air, water and nutrient relationship than a heavy clay soil. A sand has what we call single grain structure. Each little particle acts as an independent unit and is not grouped together in granules or aggregates. The air supply is adequate or excessive. Water and nutrients are limiting factors. Soil granules are not present. The surface seals over during hard driving rains. Wind and water erosion are frequently a problem. The other extreme of soil structure is found in the heavy clay soil. The clay particles stick together forming clods instead of true soil granules. The clods are dense and have little air within the clod. Unless large clods are broken down with tillage implements or by freezing and thawing the seedbed is usually not favorable for optimum plant growth. Clay soils have a high water holding capacity. They usually have low permeability. As a result, clay soils are frequently worked too wet. This destroys soil structure and forms clods. The moisture content is increased and the air supply decreased. Fall plowing is a common practice to allow freezing and thawing to mellow the soil down. Studies are needed to determine ways and means of developing and maintaining air, water and nutrient relationship favorable for optimum plant growth in sandy and clay soils.

Silt loams and loam soils usually have more favorable structure than sands and clays. Silt, clay and organic matter is bound together into granules. A high percentage of granules is favorable to air, water and nutrient relationships in the soil. But not all silt loam soils have good structure. Soils that are mostly silt with only 10 to 12 percent clay depend almost entirely on organic matter for the formation of soil granules. Soil structure is usually not stable in these soils because the granules

break down as the organic matter decomposes. Soil management practices to supply an abundance of organic matter and care to avoid over working with tillage implements are important on these soils. Silt loam soils that contain from 25 to 30 percent clay well supplied with organic matter are conducive to soil structure formation.

Crop Rotations

Probably the most important single factor affecting soil structure is crop rotation. *Corn, cotton, soybeans and other intertilled crops destroy soil structure. Grasses and legumes are structure builders.* The proportion of grasses and legumes to intertilled crops to maintain favorable soil structure varies with the soil and climatic conditions. To maintain organic matter and soil structure, most soils will require at least as many years of the meadow or pasture crops as intertilled crops in the rotation. Some soils will require twice as many years of meadow as intertilled crops to maintain soil structure. Other soils, with application of barnyard manure, may be able to stand a higher percentage of intertilled crops than pasture and meadow crops. Research on crop rotations is in progress now but is limited to a few soils. Much additional research is needed to determine the crop rotation and soil management practices necessary to maintain soil structure on different soils and under different climatic conditions.

Crop Residues

Crop residues on or near the surface help to maintain soil structure. Hard driving rains break down soil granules unless the granules are very stable. When granules deteriorate the soil runs together. The granules in most soils in this country are not stable to the beating action of hard driving rains.

Crop residues when left on the surface are effective in conserving soil and water. But their use brings up problems in crop production. Residues on the surface interfere with present cultivating equipment. Revision of existing machines or development of new ones will be required, before farmers generally will accept practices that leave residues on the surface.

In the Corn Belt the corn borer annually takes its toll of millions of dollars. The entomologists tell us that the most practical method of control is to turn under cornstalks and residues. This is easier said than done. Farmers find the large stiff stalks of many hybrids difficult if not impossible to cover completely. If this is the control to be used, better rolling coulters and proper understanding of adjustment of plows will be required. Another solution to this problem would be by use of shredder attachments on corn pickers to kill corn borers. We heard much about this a few years ago. I am now told by engineers that shredder attachments are not feasible, because the average farm tractor lacks power to handle the picker and shredder. This is a challenge to the engineers and implement manufacturers because shredding of stalks and returning residues to the surface has several advantages. *First,* shredding the stalks assures that they go back on the land where they will help protect the soil from washing during fall and spring rains. *Second,* the organic matter is returned to the soil instead of being raked and burned in the spring as too many farmers are still doing. *Third,* it eliminates the need for a stalk cutter, disk or other implements that are commonly used to cut the stalks before plowing. And finally, it eliminates the interference of cornstalks in the cultivation of the crop which really is largely in the farmers' minds anyway.

The increased acreage of soybeans in the Corn Belt during the war years has intensified the problem of how to use the soybean straw spreaders. Many of the spreaders in use do not operate satisfactorily. The soybean residue drops to the ground in large bunches. Plowing through unspread soybean straw certainly is an unpleasant task. It is not surprising, therefore, to find farmers raking soybean residue and burning it, destroying much valuable organic matter. The soybean crop has been considered an erosion hazard. Recent studies show that when the soybean straw is spread over the soil surface, erosion is less than from comparable areas grown to corn. Soybeans leave the soil loose. If unprotected, erosion may be serious. The residues protect the surface, water uptake is rapid and erosion is reduced. Wider use of straw spreaders now available and of improved spreaders or shredders is needed to help solve this problem.

Tillage Practices

Tillage practices that leave furrows on the contour reduce runoff and erosion. On permeable soils large furrows such as formed by the lister may be used. On impermeable soils water stands in large furrows and crops are drowned out. We need more research to show which soils are suitable for listing and the soils on which listing can't be safely recommended.

Tillage practices influence soil structure. Plowing land too wet destroys soil structure. This is easy to explain. Soil particles when well lubricated with water are easily pushed together in plowing or cultivating. The original granules are destroyed. Clods are formed. Structure of this type is not favorable for maximum plant growth.

Heavy machinery compacts the soil. Compaction decreases the size of the large pores. This leaves air, water

and nutrient relationships less favorable for plant growth. Let me site an example of how driving a tractor over the land when it was too wet affected the rate at which water entered the soil. On the Soil Conservation Experimental Farm in Page County, Iowa, level terraces have been used for years. The Marshall soils take up water rapidly. Even following heavy rains water has not stood in the terrace channel for more than 30 minutes. Two years ago a tractor was driven twice along the channel when the land was too wet to plow. After the next rain water stood in the terrace channel long enough to drown out the clover crop. Another question that needs answering is: Do tractor tires compact the soil in the bottom of the plow furrow? In time will this develop an impervious layer that will limit root penetration?

To prepare a seedbed six to eight inches deep is not enough. Plant roots need to go much deeper for an adequate supply of water and nutrients. Extensive areas of soil are known where plant roots are limited to the surface few inches because of an impervious unproductive clay subsoil. We generally have believed there wasn't much that could be done about this. Recent studies in Missouri on the heavy claypan soils show the possibility of mechanically loosening the subsoil clay layer, and adding nutrient material to increase root development and crop yields.

The use of special plows to mix the soil several feet deep suggests another solution to the problem. The surface 12-18 inches of flat claypan soils is mostly silt, low in clay and organic matter. The subsoil is a heavy plastic clay. Without clay to bind soil particles together, the development of soil structure depends on organic matter added by the meadow crop in the rotation. Soils with more clay form more stable and lasting structure than soils low in clay. The mechanical composition of the soil would be improved if some of the clay subsoil was mixed with the silt at the surface. Then with lime, fertilizer and a crop rotation to add organic matter it is still possible to improve soil structure and crop growth. Research is needed to determine the feasibility of this practice.

The first operation in the preparation of a seedbed is to stir the soil with some implement. Many have been used. Some are adapted to one set of conditions and others work better under other conditions. The plow, the lister, the disk, the subsurface tiller and roto-tiller and various modifications of these implements have and are now being used in the initial preparation of the seedbed. Let us look at some of the work we accomplish with these implements and point out their strong and weak points.

Figure 1. Planting corn on the contour with the loose-ground lister. The furrows on the contour are effective in conserving soil and water.

The Plow

The plow is the most widely used implement for primary seedbed preparation on farm lands of this country as well as other countries. On heavy grass sod, it is still the most effective and economical implement now available. It turns the soil over and loosens it perhaps more than any other tillage implement now in use. It buries or partially buries the organic matter. The ground is left bare. Erosion can be serious on unprotected land.

The plow has been condemned as an erosion hazard. It has made possible rapid exploitation of our soils. However, serious erosion of our farm land is mainly the result of high acreages of soil depleting, erodible intertilled crops, and low acreages of soil conserving meadows and pastures. We have plowed steep slopes without using conservation practices such as contouring, strip cropping and terracing to control erosion. We have been slow in recognizing that our soils are washing away and "wearing out". Instead, too many believe that to plow, plant, cultivate and harvest is all that is necessary.

The plow is still the most effective and economical implement for preparing seedbeds on heavy grass sods. Supporting conservation practices will be required regardless of the tillage implement. When these practices are used, the plow with some modifications for leaving the residues on the surface or mixed with the surface two or three inches of soil, is still the number one tillage implement.

The Lister

On some soils the lister is used for planting corn, soybeans and cotton. The lister is an implement that opens furrows and plants the seed at the bottom of the

furrow. It has several advantages where it can be used. About one-half as much time, power and labor is required to plant corn with the lister as compared with corn surface-planted on plowed land. Weeds can be controlled easier on listed corn than with plowing and surface planting. With rows on the contour, listing is about twice as effective in conserving soil and water as surface-planted corn. On soils suited to listing, yields from lister planting are as high or higher than yields on plowed land. But with all the advantages of listing, there are limitations to its use. Our studies in Iowa show that stands of corn were ten percent lower on listed corn than on corn surface planted on plowed ground. This is not surprising since with listing, the crop is planted at the bottom of the furrow in cool, wet soil without previous seedbed preparation. Revision of the present lister and provision for a better seedbed at the bottom of the furrow should be helpful in improving stand and overcoming nutrient deficiences. The entire soil area is not loosened by the present listers. If a method could be developed for loosening the soil, greater root development and plant growth would occur.

On eroded soils the lister plants the seed in the subsoil which is often unproductive. The use of commercial fertilizers may help overcome the nutrient deficiencies frequently found under these conditions. Little work has been done to show the amount, kind, method and time of application of fertilizer to crops planted with the lister. Legumes and grasses regularly in the rotation will also help improve the structure of the subsoil. The lister is being used to advantage on many soils throughout the country. Its use probably could be expanded to advantage if studies were available to show on which soil it can be used and the soils where it isn't suited.

The Disk Harrow

The disk harrow is an implement found on most farms throughout the country. It is a very convenient tool and when used properly and at the right time is an effective tool in seedbed preparation. It does not work well in rocks. It prepares the seedbed with a cutting action. Any implement of this type, especially if used excessively, will cut and destroy soil aggregates and unless judiciously used can be quite harmful. The general tendency is for farmers to disk too many times. This often is necessary to prepare what they think is a satisfactory seedbed. At best, the disk prepares a shallow seedbed, cutting not more than two or three inches deep unless it is a disk tiller or disk plow and unless it is heavily weighted. Most disks are not kept sharp and unless the soil has unusually good tilth too many operations of a disk are required to make it an economical method of seedbed preparation. The disk mixes the residues with the soil. Mixing the residue with the soil reduces its effectiveness in protecting the soil from the beating action of raindrops. Studies show that plants on disked land develop nutrient deficiencies, the plants are smaller and the yields are lower. It appears that seedbed preparation with the disk is limited to fields following soybeans or other crops that leave the soil loose and seedbed preparation simple.

Subsurface Tiller and Field Cultivator

These implements prepare a seedbed by sweeps working under the surface and loosening the soil without inverting it. The residue of small grain or cornstalks on the surface are effective in conserving soil and water.

We have had studies on 60 fields in Iowa during the last six years comparing yields of corn when the seedbed has been prepared by plowing, listing, subsurface tilling and disking. Corn on subsurface-tilled fields has consistently yielded less than when the land was plowed. The stand on subsurface-tilled plots was as good as on the plowed land. The plants were smaller, the stalks were smaller and in many fields, where poor soil management practices had been followed in the past, nutrient deficiencies developed. Measurements show that the soil is more compact and not as well aerated on the subsurface tilled plots as on the plowed plots. If we use the yields and general appearance of the plant as a guide, the seedbed prepared by the subsurface tiller was not equal to the seedbed prepared by plowing. We found that it was not practical to prepare seedbeds in sod with the subsurface tiller unless a disk was used in addition to the tiller. With all of the desirable features of the subsurface tiller and field cultivator we should direct investigations towards the development of a machine that will prepare a seedbed to produce yields as high as on the plowed land and still retain the desirable features of leaving the residue on the surface.

Roto-Tillers

Recently, there has been much interest in the roto-tiller and similar tillage equipment. These machines have been used very effectively in seedbed preparation for vegetable production. A number of farmers have tried roto-tillers under general farm conditions. Reports of their success are conflicting. Some say they work and others say they don't. Tests by agricultural engineers indicate the power requirements of several of the roto-tiller machines is in excess of that of the average farm tractor. This being the case a separate motor unit is required. Such a machine is not an economical unit on the average farm. The greatest drawback to the roto-tiller is that it stirs the soil more than most other tillage

(*Continued on page* 104)

Photo by Victor R. Boswell

A rare sight in Japan—extremely steep slopes cultivated with no soil conserving measures. Near Nagano City, Nagano prefecture, Japan.

Rice irrigation reservoir and terraced hillsides near Ushimado, Okayama prefecture, Japan.

Photo by Victor R. Boswell

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Photo by Washington National Guard

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Photo by U. S. Forest Service

melting snow in the mountains means life to
the valleys below.

Photo by Soil Conservation Service

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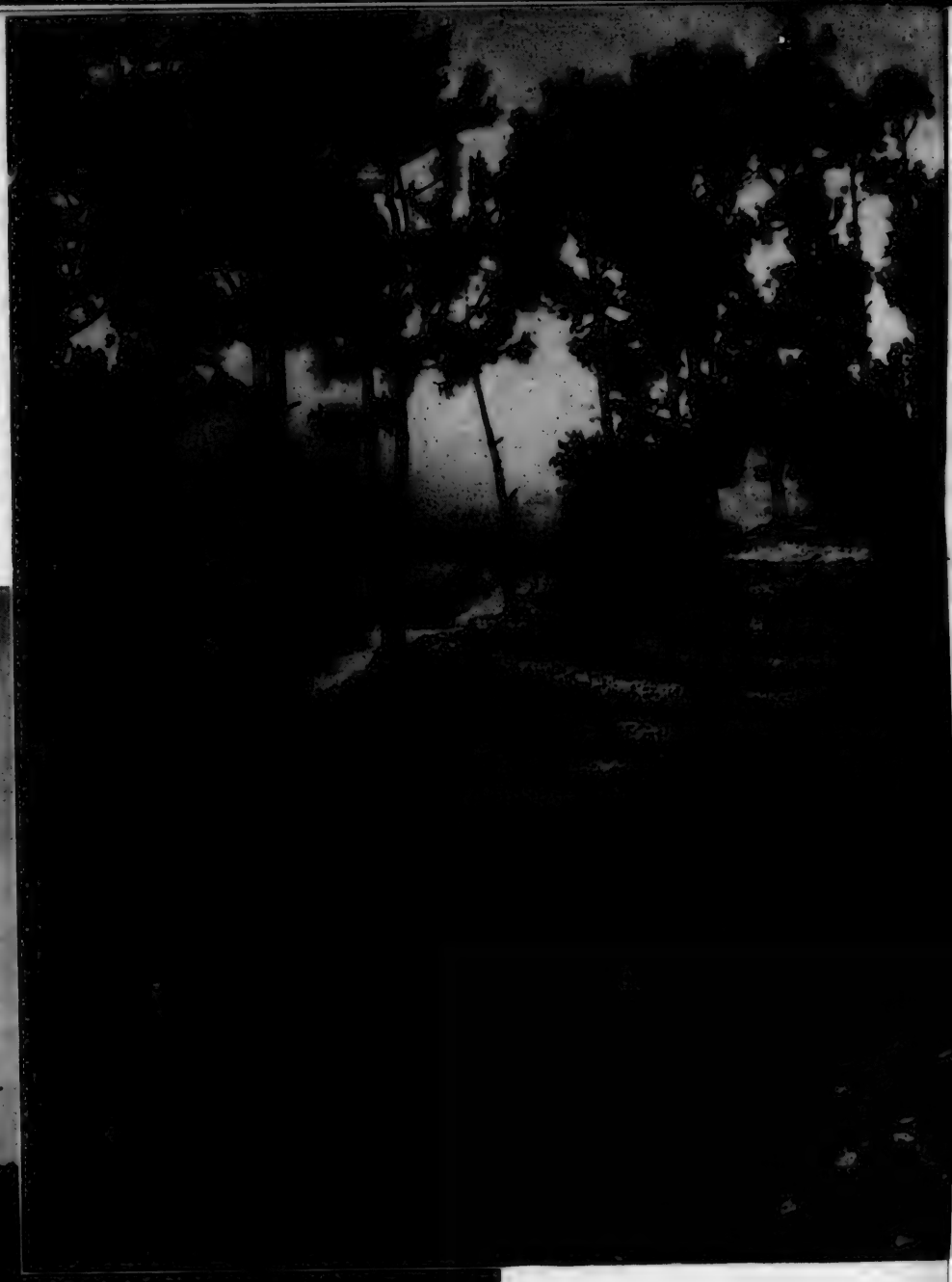
Photo by Soil Conservation Service



Bench terraces made by the Indians with hoes in Guatemala and planted to small grain.

Photo by Ernest G. Holt.

Burned new ground in a canyon near Tegucigalpa, Honduras. This area was later planted to corn.

Photo by Ernest G. Holt.

Planning for Sound Production Credit

LAURENCE F. WHITTEMORE

THIS PAPER by Laurence F. Whittemore, President of the Federal Reserve Bank of Boston was presented before the Southern New England Chapter of the Soil Conservation Society of America at the American Academy of Arts and Sciences, December 13, 1947. Mr. Whittemore is an outstanding leader in the banking industry. His knowledge of agriculture and the need for conservation has done much to help bring about the development of a basic conservation program for New England.

SOIL CONSERVATION as an idea has achieved respectability. No one would have the temerity to be against soil conservation, any more than he would be against "sound fiscal policy" or efficient government, or motherhood. On the other hand, to be "for" an idea like soil conservation implies the obligation of making up your mind about what soil conservation is. What is more important you cannot just accept the idea of soil conservation. If the idea is to make any sense, you have to be prepared to do something about it. What you do depends on what you think soil conservation is.

To get down to cases, what do we expect soil conservation to do in New England? *First*, I think we want a program that will develop our soil resources to their highest capacity and keep them there. That is something more than merely preventing erosion, although that is important. Our soil resources should be preserved because they are worth preserving. Productive soil is the foundation of New England's agricultural economy. It is the source of the income of a group of farmers who outnumber the farmers of Kansas. The value of the agricultural products marketed by New England farmers in 1946 amounted to 566 million dollars. If we add the sawmill and roadside value of New England's forests to this total the income from the land amounts to more than 650 million dollars.

If we are to maintain and increase that level of profitable employment on the land in New England there are two major problems to be solved. Capital and labor employed on the land must be made sufficiently efficient to compete with capital and labor employed in the services and industries of New England. Soil conservation protects the basic capital of agriculture which is the productive capacity of the land. Furthermore, with the careful farm planning that is part of our present soil conservation programs, the productive factors on our farms can be organized to give optimum yields.

Grass Replaces High Priced Grain

Grass is the foundation of New England's dairy industry. The more feed our farmers can get from better hay and pasture, the lower the cost of producing a quart of milk. Grass not only keeps the soil in place and holds the water where it is needed, it takes the place of high priced grain. That brings me to the *second* point. Soil conservation makes it possible for New England farmers to compete successfully with farmers in other regions. It is important to remember that the major potential competitors for the New England farmers' markets are those states in which soil conservation programs have had the longest and most successful history.

Historically the New England farmer has depended on the nearness of his market to give him the necessary competitive advantage. With the improvement of transportation and more efficient marketing methods this advantage is disappearing. The New England farmer must be able to meet his western competitor on his own ground, as an efficient producer. In the final analysis that means fewer trips to the grain store and more farming.

This is where the banker comes into soil conservation in the sense I have been using the term here. If New England farmers are going to do more farming, if they are going to make their soil more productive, if they are going to adapt their land to the greater efficiencies of mechanized agriculture, many of them are going to need credit.

In the light of present inflationary pressures, any discussion of credit must of necessity be hedged with the proviso that until that pressure lessens credit must be limited to those uses which add to the total flow of goods immediately and which are needed to arrest a decline in production. This condition may eliminate lending to farmers for long time capital improvement at the moment. However, when economic conditions level off, we must be in a position to provide the kind of credit that will be effective in expanding the labor and capital efficiency of agriculture.

Until that time we must content ourselves with adjusting our concepts of credit to the job to be done. For farmers who have farm plans ready to be put into action the wisest course is to make as much of a beginning as possible using their own labor and funds, and confining such action to projects that will immediately cut their production costs and add to their efficiency.

In spite of these qualifications that the emergency of the moment makes necessary, we can now consider the kind of credit New England agriculture will need in the future.

If credit is to do a useful job in helping the New England farmer to do a better job on his land it must be based on a well conceived program. I should like to outline in general terms what I think should be the criteria for sound farm credit.

In the first place, there will be no point in making a loan to a farmer unless there is a reasonable assurance that the loan will increase his income. *To plot a course toward sound productive credit we must have a technique for measuring both the physical and economic capacities of our farms.*

Farm Plan is an Important Instrument

The soil conservation districts, now firmly established in New England, can help to give one of these necessary measurements—the farm plan. The plans which conservation technicians make for cooperating farmers tell what the farm is capable of producing. It also spells out how those soil resources can be made more productive by drainage, pasture improvement, and stone wall removal. What the farm plan does not do is weigh the economic factors that are basic in land use development. There is no point in improving a farmer's pasture if he will have no market for his milk. More and better roughage for a farmer who is unable to buy the cows to use that roughage is not an increase in the productive capacity of his soil if by production we mean useful production. In other words, soil conservation does not stop with the soil conservation plan. Such a plan is just the beginning. To be complete it must be adjusted to the economic potentials of the farm.

If the farmer does not have the ready cash to finance his soil conservation and land use development program he must have credit. In the final analysis, whether or not he gets such credit depends on the flexibility of our banking system. It might be argued that the only question here is whether the would-be-borrower has the assets to back his loan. That, to my mind, begs the question. The basic problem is, what are a farmer's assets. From the point of view of their value to a lender one of the most important assets would be the capacity of his soil to produce profitably over a period of time. Obviously, *a successful loan to increase productive capacity cannot be repaid by depleting capital resources.* If such a loan is justified, repayment should come from increased earnings made possible by the loan. That leads to the logical conclusion that the basis for providing the loan in the first place should be a well defined program that would promise such increased earnings.

From this it follows that soil conservation is the beginning and credit is the end of a process by which a full and permanent use of our soil resources can be made a reality. We cannot escape the fact that agriculture is in a state of transition with a shift from small to larger units and rapidly increasing mechanization. If the farmers of New England are to maintain their competitive position with the rest of the country they need to be in a position to make this transition swiftly and smoothly. It is up to farmers themselves now and our credit institutions in the future to finance this transition in such a way that the net result will be a more stable and prosperous agriculture.

Effective Credit Based on Long Run Condition

To say that a loan is adjusted to earning capacity is not enough of an answer to this problem. To be more specific, it should be adjusted also to the time when that earning capacity is realized. The lending policies of our commercial credit agencies have grown up to serve enterprises which need short term loans to finance a rapid turnover of goods. A farm, on the other hand, is a long run process with occasionally violent price and production fluctuations in the short run.

An effective credit policy for land use development should recognize these long run conditions. From the point of view of the farmer a prime consideration would be the possibility of postponing repayments on a loan until his development program begins to make a profitable return. A farmer would also prefer to borrow money with the provision that further loans would be advanced as they would be needed. If he is expanding his dairy herd he begins with his land. However, if he is going to start on such a program he wants to have reasonable certainty that he is going to be able to finish it. A farmer would prefer not to borrow money to increase roughage production without the assurance that he would be able to capitalize that improvement with a larger herd and equipment to care for it when the time comes.

Finally there is the question of the time schedule of repaying loans. In the short run farm income is relatively unpredictable. Foreign demand, domestic prices, weather, all influence both the farmer's costs and returns. If a loan is not to become a heavy millstone around his neck the farmer would want the plan of repayment to recognize these variations in income by postponing a portion of the amount due to be repaid when conditions are more favorable.

These features run counter to conventional banking practices. Even though they be only token payments, bankers would want some repayment to be made annu-

(*Continued on page* 90)

Some Polish Soil Problems

E. N. MUNNS

E. N. MUNNS has been a frequent contributor to the JOURNAL. This paper comes as a result of a mission to Poland. He discusses some of the agricultural problems with which the Polish farmers are confronted. Mr. Munns is Principal Silviculturist in Charge of the Division of Forest Influences Research, Forest Service, United States Department of Agriculture, Washington, D. C.

POLAND IS A LITTLE KNOWN COUNTRY. With a population of around 23 million people, it occupies an area of about the size of Ohio, Indiana, and Illinois. It is largely a glacial plain extending northward from the Carpathian Mountains some 350 miles to the Baltic Sea. Its east-west axis is about the same length.

The northern 75 percent of the country is a great sandy plain in which are occasional rolling lands, mostly dunes and moraines. Farther south are rolling hills gradually approaching the Carpathians. In this piedmont section are the more fertile soils, some of loessal origin and others from limestone, granite and other rich parent rocks. In a few places are sandstone soils. Along the stream valleys and especially at the mouth of the Vistula, is sedimentary material. Swamps of both the low and high moor types are fairly common. Two great rivers, the Vistula and the Oder, drain the country.

The people of Poland are predominantly agricultural: some 60 percent of its people live off the land. Before the last war they produced rye, potatoes, pork, and poultry in sufficient volume to build up an export trade. Other crops included wheat, oats, barley and sugar beets. Now, Poland can barely feed itself. Mineral resources other than coal are limited. Industry, prior to World War I when Poland was divided between Austria, Germany and Russia, was limited. In the interval between the great world wars, Poland made strenuous efforts to industrialize, but these were nullified when Germany marched into Poland.

Polish soils have been cropped for many centuries. Their natural fertility was generally low but had been built up and maintained by fertilizers, chiefly stable manure. The large number of animals kept on farms made this possible. Thus a 10 hectare (25 acre) farm in 1938 would have 3 horses, 8 cows, 6 pigs, 3 sheep, besides poultry (chickens, geese, or ducks). Chemical fertilizers were not in general use because most Polish farmers were too poor to buy them: when they did, the fertilizers were normally used on special crops such as tobacco or sugar beets.

Loss of Resources is Heavy

The tremendous loss of farm animals—from 60 to 80 percent—during World War II resulted in a great decrease in available organic manure. Although the numbers of poultry and hogs now approach pre-war figures, the numbers of cows and horses are still low. Consequently it will be 5 years before the pre-war level of livestock number can be reached. In addition Poland has suffered a 30 percent loss in population further reducing the available supply. Although since the war, the Polish government has made strenuous efforts to overcome deficiencies in manure by developing a chemical fertilizer industry, it still has far to go. Today (end of 1947) the Polish acre receives about 10 pounds of nitrogen, 6 pounds of phosphoric acid, and 12 pounds of potash less than pre-war. This has resulted in a decrease in crop yields.

On a basis of calculated grain yields, this reduction amounts to 25 percent, but actually it approaches more nearly 50 percent because of the cumulative soil depletion. Many years will therefore be required to rebuild the soil without composting.

Most Polish soils are so poor in nutrients that crops show mineral deficiencies of different kinds. Nitrogen is generally lacking. Pressures for grain are such that few legumes are currently grown. Some lupine and clover is produced, but crop rotation as a regular practice is yet to come. Composts as such are relatively unknown, but most waste plant material is added to the soil anyway.

Phosphates are the scarcest of all fertilizers. Polish phosphate production is limited by the relatively small size of industry as well as by the lack of basic materials. However, most of the soils belong to the group of podsolized gray-brown forest soils so that with their high acidity, they are more or less suspect as regards phosphate fixation.

The needs of soil for potash has been met in the past by manure applications. Greater yields in the future cannot be obtained without more potash making it perhaps the key to agricultural recovery. Indications are that Poland may find deposits of sufficient value to permit a potash industry, in which case Poland may again develop an export trade in grains.

Land Treatment Need are Many

A more generous application of fertilizer however will not solve Polish soil problems. The moister parts of the

country contain the poorest soils: the farmers on these soils are desperate in their efforts to sustain an agriculture at all. The drier parts of Poland have the best soils: the nation faces severe food shortages unless crop yields can be stepped up. Which soils should be given the fertilizers? The poor soil will respond readily but the yield will be low. The good soils can't respond without water. Thus social and national needs clash, presenting the Government with a most difficult problem.

Most Polish soils are acid. Lime applications are therefore widely needed. However those needing lime the most are farthest from the source. Transportation has been so damaged, production methods are so primitive, and the need of lime so poorly recognized that many years will be required before Polish farmers learn how and when to use lime.

Over-application of lime has occurred near some of the sugar beet factories. During the German occupation, many farmers were told to use more lime than the land actually required. At first the sugar factories sold the lime cheaply, but when the demand fell off, they gave it away. Finally the Germans ordered the farmers to use it at rates greatly in excess of needs. Now some of the soils are sick.

The pressure of people on the land has been great. It has resulted in pushing agriculture onto outwash sands that were too poor to support it, into cultivating slopes too steep for continued farming, and into grazing steep lands too heavily.

At present, there are between 1 and 2 million acres of sandy soil, too light, too dry and too infertile for agricultural use. Some of these sands, formerly farmed but now unoccupied, are blowing. In some places where the vegetation on inland dunes has been depleted by grazing, fire or more often by war activities, the sands are encroaching on agricultural lands. All such submarginal agricultural lands the Poles are nationalizing in one way or another and devoting them to timber production. Land classification other than by foresters has proceeded slowly.

Drainage and Irrigation Needed

Plagued by repeated drouths, Poland needs some form of supplemental irrigation. Most of the needed water can be readily found in relatively shallow underground sources or in nearby streams. Applied by ditch or sprinkler, such artificial watering would markedly increase crop yields and in times of severe droughts would save the crop. Already here and there, where equipment is available, supplemental irrigation is being used on tobacco and potatoes with marked success.

Drainage is a major problem in the delta region of the Vistula River. Here are some 250,000 acres or more of deep alluvial deposits which since the turn of the century have been at least partially ditched and the water pumped out. During the war, the dikes were broken and many of the pumps removed or damaged. Only now, three years after the war, have the dikes been repaired and the flood waters lowered. The ditch banks meanwhile have so slumped and the ditches filled that a major drainage operation is required. Lacking equipment, drainage rehabilitation is being attempted largely by hand or with horses that are far too light for the heavy work. Considering the magnitude of the task, the poverty and undernourishment of the people and their attendant sicknesses, the lack of housing, the methods used, the lack of tools and power equipment, their unfamiliarity with drainage work, it is safe to say that it will be many years before the task is done. Then, if the soil is not ruined or badly damaged by their plowing and cultivation practices in efforts to grow grain, this section can become as great a dairying section as parts of Holland and Denmark.

Soil Erosion is Extensive

Erosion occurs on some of the rolling loessal and limestone lands. Under a continuous cover and good cultivation practices these soils would retain their structure and fertility. Sheet erosion over centuries of use has removed much surface soil, and in places has resulted in gullying. The latter is not as destructive as one might think, because the Polish farmer is extremely land conscious. By working the land intensively, by a crude form of terracing, and by hard work—aided by the fact that at times when the ground is bare most rains are gentle—the Polish farmer has avoided a gully pattern that has wasted away our own lands. However some side roads have been "worn" 10 to 15 feet deep, and when the farmer is asked why this is so, he explains it was always so.

In the mountain areas, sheep production for cheese, meat and wool has increased as an outgrowth of the war. Formerly, many more cows were produced, but the peasants learned that a cow could not easily be hidden and that beef was requisitioned by armies while mutton was not. As the cows were taken, the farmers turned to sheep which also multiplied faster. Now the sheep population in the mountain areas has increased to the point where the timber-line forest is seriously damaged, high mountain meadows are being destroyed, and rock slides and avalanches initiated. In some parts of the piedmont the excessive numbers of sheep are responsible for serious erosion.

The rivers and waterways of Poland show the effect of these heavy pressures on the land. In the Vistula, the

constantly shifting sand bars are holding back the development of water transportation. In the Oder, dredged and regulated to a marked degree by the Germans, the lack of maintenance during the war years has resulted in a marked shoaling. Reservoirs in the mountain areas also contain considerable quantities of sediment with more in the stream channels on its way down.

Polish Farmers are "Backward"

Whether Poland can or cannot overcome some of its soil and land use problems remains to be seen. Poland is a nation with ambition, determination and energy. It has suffered as no other one nation has suffered, not only in the recent war but repeatedly for it has been the door mat of Europe. Poland takes great pride in its history, its culture, its arts. It also takes great pride in its accomplishments. But it is prostrate, desperately poor, lacking in resources and technical skills. Its cities, villages and homes have been extensively damaged or destroyed. Poland is virtually starting from scratch in its efforts to rehabilitate itself.

The Polish people are essentially rural in their thinking although the Government is urban. The Polish farmers use primitive equipment, are given to hand labor, and are in a sense "backward." They are tied to tradition and are somewhat superstitious. Though they may be uneducated, and many cannot read or write, they are intelligent enough to grasp basic principles. They are suffering today from the fact that so many of their scientific and professional leaders in agriculture went to extermination chambers, to concentration camps, or forcibly to Russia. In agricultural methods they are perhaps 50 to 100 years behind America of today. The people are such however that when they grasp new and modern methods they have the inherent capacity to put them into practice. Such a people will go far in making their country truly great, despite all the handicaps of poverty and of soil and climate.

Soil Conservation Work In Nurseries

JOSEPH A. ABRAHAMSON

JOSEPH A. ABRAHAMSON is associated with Mount Arbor Nurseries, Shenandoah, Iowa. He has been responsible for the development of a complete conservation program on 1800 acres of land used entirely for the growing of nursery stock since 1943. Mr. Abrahamson also devotes a part of his time to research, development of new nursery equipment, and insect and disease control.

I WOULD FIRST LIKE to give a brief history of soil conservation work that has been done in the nursery industry. There have been isolated cases where individual nurseries have done a small amount of soil conservation work as we now know it for as many as 20 or 25 years. One case I have in mind is the work that has been done by Chase Nursery at Chase, Alabama, where they have practiced soil conservation work on a 19 acre field for 25 years. However, the bulk of the conservation work in nurseries has been done in very recent years.

A large beginning was made at Neosho, Missouri, by Neosho Nurseries about 1938 or 1939. Several other nurseries made their start about 1939 or 1940 with the help of the Civilian Conservation Camps. This is true of the Shenandoah area when the Mount Arbor Nurseries began their work in 1939. This beginning did not amount to very much however, because most of the nurserymen did not know how they were going to make their plantings and carry on other operations on contoured and terraced land. This beginning did create enough interest to make them see that the work was going to have to be done and they were going to have to learn more so that they could fit their operations to soil conservation work.

In order that you have a better understanding of some of the nurserymen's problems, it is well that I explain in brief some of the operations that take place in the nursery industry. Nursery operations are, by their very nature, about as hard on a piece of land as any kind of agricultural pursuit. For example, corn, one of the most soil-depleting crops, leaves the soil without cover about four months a year; the clean-tillage practiced in growing nursery stock may leave the soil uncovered 12 months of the year. Farm cropping removes the tops of the plants; nursery culture removes roots as well and may remove considerable soil. Because of the necessity of removing stock from the field while it is dormant in the late fall and early spring, digging must often be done when soil is wet. The resultant trampling and packing by men, teams, digging equipment, tractors and trucks causes severe puddling and breakdown of soil structure. This physical pommelling, along with exposure to erosion, is in fact, the principal reason nursery cropping is so hard on soils.

Most large nurseries grow a wide variety of stock. The firm which I represent grows approximately 1500 different varieties of trees, shrubs, bulbs, etc. The growing period of this wide variety of stock ranges from one to ten or twelve years; perennials and bulbs requiring one to two years; most shrubs, two to three years; conifers and forest trees require from six to twelve years. Most plantings are made in the fall with some stock being planted in the spring. In order to have a complete inventory of the stock on hand, field records are made each year. These field records list the many varieties of stock grown, how many plants of each variety are growing and what size or grade these plants will make by digging time. Large nurseries have difficulty in keeping these records accurate on contoured rows because of the number of point rows involved. Most of the digging operations are carried on in the fall. The problem of digging nursery stock on terraced and contoured land is probably the greatest stumbling block to the extension of conservation work in the nurseries. Briefly, the conservation program has been held up in the nurseries because of the following:—

1. Difficult digging or harvesting operations.
2. Difficulty of changing farms over to conservation plan due to the long growing period of some of the stock already planted on a particular farm.
3. Keeping of field records on contoured lands has been more of an excuse rather than a problem.
4. True rotations in large operations are almost impossible to plan.

What is Being Done

In order to reflect the views of industries, I contacted a number of the large nurseries throughout the United States that I knew had done some conservation work or were seriously thinking about it. The following firms were contacted:—

Andrew Nursery Company, Faribault, Minnesota
J. V. Bailey Nurseries, St. Paul, Minnesota
C. R. Burr & Company, Manchester, Connecticut
Chase Nursery Company, Chase, Alabama
Henry Field Seed Company, Shenandoah, Iowa
Jackson & Perkins Company, Newark, New Jersey
Perkins-DeWilde, Shiloh, New Jersey
Stark Brothers' Nurseries, Louisiana, Missouri
D. Hill Nursery, Dundee, Illinois

Figure 2. A planting of young azaleas on the contour at the Perkins-DeWilde Nursery Company, Shiloh, N. J.

I would like to summarize the soil conservation practices listed in the reports received from these firms. They are:

Contouring: Most firms contacted are using this practice to some extent because it is easy to follow.

Terracing: All are using terracing to a large or small degree where they need it. One firm, C. R. Burr & Company, reports using cross cultivation on terraced land.

Strip Cropping: Two firms report use of strip cropping: Andrews' and Burr's. Burr's use strip cropping on all their leased land. They apparently do not care to go to the expense of terracing leased land. All firms reported the use of grass water-ways where they are needed.

Gully control structure and drainage work: D. Hill Nursery, Dundee, Illinois, have made extensive use of gully control constructions, mainly the use of weir-notched dams and drop inlets. C. R. Burr & Company report the use of drainage work.

Crop Rotations and Cover Crops: The reports give us some interesting pictures of the type of crop rotations that are being used or attempted by these firms.

Andrews Nursery, as well as our firm, has gone to the expense of buying additional land so as to carry out some form of crop rotation. Most northern firms use a brome-alfalfa for two to four years for soil building. Andrews use this crop for three years where a three year nursery crop is to follow and for two years where a two year nursery crop is to follow.

Bailey's Nurseries plan to keep about one-third of their land in legume and grasses at all times.

C. R. Burr Company at their Manchester, Connecticut, plant lease approximately 60 percent of the land. Their leased properties are seeded down for a year or two before placing them in nursery crops. Burr's operations at Cape Charles, Virginia, brings up the problem of using a rotation with a suitable legume crop for nursery stock production in the South. The problem there is to find a soil building crop that is also a nematode resistant. Too many of the legume crops used in the South are not nematode resistant.

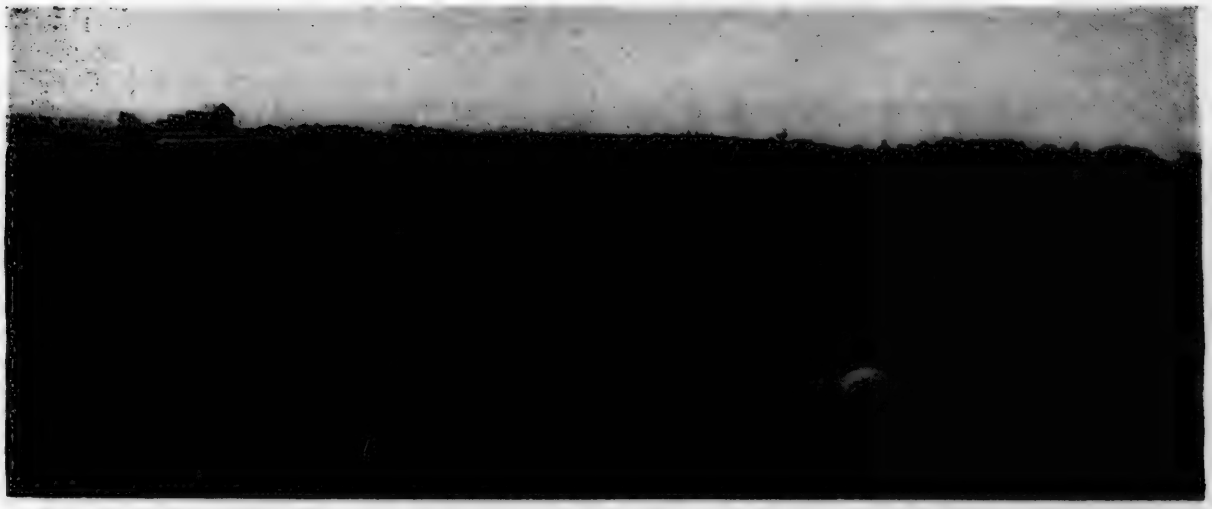


Figure 1. A scene showing soil conservation operations on a nursery farm at Shenandoah, Iowa. It also shows fruit stocks grown on the contour between terraces. As will be noted, the terraces are in grass, because in nursery practice it is not considered desirable to farm the terraces.

Chase Nursery Company at Chase, Alabama, are great believers in crop rotation and mulch tillage. They use Summer plantings of vetch and corn, also vetch and soy bean cover crops that are disced into the top few inches of the soil. They also plant vetch in between rows of their nursery stock in September which is later disced or cultivated into the soil in the spring.

At Shenandoah we are using a three to four year seeding of brome-alfalfa returning the land to nursery stock production for six to eight years. Cover crops consist of mainly buckwheat broadcasted in our one year plantings of nursery stock in September or October. Most firms report that they use considerable amount of barnyard manure and quite a number report the use of commercial fertilizers. Commercial fertilizers are used for the production of nursery stock in the East and South. We have not been able to find any great benefit from the use of commercial fertilizers for growing nursery stock in our Marshall soils in southwestern Iowa.

Discussing the work that has been done by the nurseries, it must not be overlooked that they have done a great deal of education work for soil conservation work. This has been done in the form of tours by individual nurserymen, programs presented at State and National meetings and Soil Conservation articles printed in their national and state publications. The Mount Arbor Nurseries at the present time has a 16 mm. film on nursery operations that contains so many pictures of conservation work that many of the nurserymen refer to it as a soil conservation picture.

Mention should also be made of the work being done by the American Association of Nurserymen through the leadership of Richard P. White and with the assistance of A. D. Slavin in preparing a soil conservation bulletin made especially for nurserymen. This will be sent out in the near future.

What Must Be Done

Most of the letters received sent out a plea for additional help from the Soil Conservation Service. Due to the large operations involved at Mount Arbor they felt it was to their benefit to hire a man with soil conservation training to establish their soil conservation practices. This would be almost impossible for most of the firms throughout the United States because of their size. Richard Holmes of Jackson & Perkins Company reports they do not feel that they can rely on private help because of one experience they had. Mr. Holmes reports, "Our place at Richmond, Indiana, which is almost new was not in the district when we first purchased the land. However, it is now incorporated in the district and it was necessary for us originally to go out and hire private individuals to go out and do the job and this proved to be an absolute headache." This farm has since been laid out by Mr. Slavin and his assistants to their satisfaction. I think that the men working with nurseries in establishing conservation plans should have a better understanding of the nurserymen's difficult problem of changing over to conservation plan. I doubt if many Soil Conservation Service personnel realizes the problems involved. There is a request and a great need for additional research work to be done to determine the nutrient levels necessary for the produc-

(*Continued on page* 102)

Planning for Sound Production Credit

(*Continued from page 84*)

ally. While lines of credit for a crop season are common, a banker would hesitate to commit himself unconditionally today to make a farm loan two, three, or four years hence. A sound banker would anticipate some ups and downs and seek to arrange a repayment schedule that would still be feasible even if times were not as good as they are now. But here again he would hesitate to make a hard and fast commitment to grant an extension two or three years hence. Instead, he would want to consider the case on its merit when the problem arose, determine whether the borrower had done his honest best to meet the terms as provided, and would proceed from there on the basis of what seemed best from the angle of both banker and farmer.

Understanding of Problems Necessary

Neither party at issue finds the viewpoints of the other wholly acceptable, but questions such as these are a challenge both to farmers and credit agencies to understand the other's problems and from that understanding, to work out a sensible plan of operation.

It is important to recognize that credit as flexible as that suggested here presupposes that the farmer who is borrowing money to carry out a land development program is a preferred risk. This will be true if the farmer is financially sound, if he has a soil conservation program which he is committed to carry out, and if that program is based on a thorough appraisal of his economic resources. In other words, he is a preferred risk because he is prepared to use his resources to their fullest capacity over a reasonable period of time.

One of the most important instruments in making farmers into preferred risks and keeping them that way is the soil conservation district program. *The need is not for more credit but rather more efficient credit.* We can no longer afford to waste our resources either through misuse or inefficient use.

This leads to the consideration of another land resource that is important in the economy of New England and one that unfortunately has a long history of inefficient use, that is, the forest land. Of the 612 million dollars New England farmers received for products marketed in 1946, some 46 million came from forest products. Under proper management the farm woodlands of New England could yield an income several times that amount. Unfortunately, the farm woodlot has come to be regarded as the backward boy of the family of farm resources, something to be exploited when possible, but worthy of no special care.

Forest Conservation Begins With the Land

In a region where forestry has so many natural advantages this attitude does not make much sense. The barriers to good forestry are largely man made: exploitive taxation, poorly organized markets, improper harvesting methods, and perhaps most important of all, an unwillingness to recognize the possibilities good forestry has to offer.

Even more than agriculture, forestry is a long run enterprise. With a 70 year rotation necessary to produce saw timber, a forest program must be projected over several human generations. That does not mean that good forest practices can promise no net income except in the distant and uncertain future. It has been demonstrated in New England that selective cutting and minimum protective practices more than pay their way and add to the ultimate net productivity of our forest resources.

Admittedly there is much to be done before we get a thoroughly efficient utilization of our forest land. But the place to start is with a land itself. This does not mean that we can neglect the inequities of our present tax structure, inefficient harvesting and marketing. The problem has to be attacked from all sides at once. But if we can get a better stand of timber, the solution of the other problems will be that much easier.

I should like to suggest that if soil conservation is to continue to be a dynamic force in our regional economy the problems of forestry should have the fullest consideration at all levels of the program. When that is done we will have integrated the use of our soil resources on a broad base. On that foundation we can build a pattern of land use that can promise a profitable and permanent use of that highest of all of our natural resources, the time of man.

BOOK REVIEWS

THE RUFFED GROUSE—LIFE HISTORY, PROPAGATION, MANAGEMENT. By Gardener Bump, Robert W. Darrow, Frank C. Edminster and Walter F. Crissey. New York State Conservation Department, Albany, New York. 1947. Pp. 915 xxxvi, figs. 127 and 4 color plates. Price $10.00.

HERE IS ONE of the most complete monographs ever written on a single wildlife species. This superbly published book is a classic in wildlife literature. It is an exceedingly comprehensive treatise and reports on a painstaking investigation commenced over 16 years ago. Within the handsome red, gold lettered binding, are facts on almost every conceivable question on the habits and characteristics of the "king" of American upland game birds. It is written in a pleasing, readable style and regardless of its size, 6¼ pounds, you will have an insatiable desire to read the entire account of this remarkable and fascinating study.

The investigations of four well-known wildlife technicians and numerous other contributors are recorded with accuracy. However, this is more than a mere game bird dissertation. It is a book about life, one that deals with that important matter of survival, since in telling of the fundamental requirements of one animal it portrays in word and picture, the multiplicity of the struggles and limiting factors of all living creatures. No phase of the basic biology, economic importance, the factors that affect abundance, or the managing of the grouse crop has been overlooked.

Extraordinary perseverance obviously was required to finish this work. The text is well organized. Commencing with records of early observers, an outline of the history, population fluctuations, era of market hunting and exploitation, and the rise in importance of the grouse as a popular sporting bird, is presented in an interesting and enlightening manner. The early efforts at artificial propagation, the period of correlated research, and the known management practices are described in detail. There is an excellent bibliography and an adequate index.

This is a splendid reference book but it will not be put on the book shelf until it has been read. Those chapters dealing with cover characteristics and shelter requirements are depicted with remarkable clarity. The illustrations which show the stages of succession through which vegetative cover passes are magnificently simple in their teaching. This is a "must" book for wildlife students, game technicians and administrators, foresters, and soil conservationists. Surely it will be used in the schools, especially in the colleges and universities that have courses in wildlife and other natural resource subjects. It is an excellent gift for a sportsman or an outdoor-minded friend.

—C. R. GUTERMUTH

USING AND MANAGING SOILS. By A. F. Gustafson. McGraw-Hill Book Company, Inc., New York. 1948. Pp. 420, figs. 190. Price $2.80.

THE AUTHOR SAYS that this book "is designed for farmers, those who work small acreages, home gardeners, and students of vocational agriculture." That takes in almost everybody except college students and those who live in apartment houses.

The outstanding feature of the book is its 190 excellent illustrations. Anyone who picks it up is not likely to lay it down until he has leafed it through and studied what they illustrate. One sees a great variety of crops and of implements employed in preparing the land for these crops and for harvesting them. There are some abandoned houses and some that show all the evidences of prosperity. Scattered here and there are a number of illustrations that have to do with removing excess water and others dealing with various phases of irrigation farming. Such problems as managing acid and alkali soils, using manures and green manures, and manufacturing and applying fertilizers are pictorially presented. One especially interesting set of drawings shows three types of old stone drains in association with the mole drain and the more modern ditching machines. The appendix gives an extended list of visual aids, with names of the sponsoring agencies.

The chapter titles are interesting in that they start off with present participles, such as getting, selecting, tilling, controlling, managing, conserving, growing, keeping, and planning. This lends emphasis to the idea of doing something about it, today, while the thought is still pregnant in one's mind.

The pedologist will not be very happy about the book because it doesn't even mention such words as podzol, chernozem, and laterite, and one finds no reference to soil series. He does find, however, an excellent relief map of the United States, others showing the loess areas and those that were covered by glaciers, diagrams of soil profiles with good, medium, and poor drainage, and an outline map of the important crop areas.

Running through the entire volume is the overall concept that the first essential in land management is to

stop erosion by wind and water and keep the soil where it is. Having adopted a program that does this, the principles of soil improvement can then be applied with reasonable assurance of success.

The author is to be congratulated on the technique employed to make the book attractive and interesting. The level of presentation is that of students in vocational agriculture.

—FIRMAN E. BEAR

HEAVEN'S TABLELAND: THE DUST BOWL STORY. By Vance Johnson. Farrar, Straus and Co., N. Y. 1947. 288 pp. Frontpiece map. $3.00.

HEAVEN'S TABLELAND is a fascinating tale about the Dust Bowl, told with all the charm and interest of a novel. Yet it is a factual account, forthrightly presented.

The book starts with a chapter that sketches the first farmer of the High Plains—Panhandle Man—who irrigated his fields before the Conquistidores reached New Mexico and Colorado. This early farmer left evidence that recurring drought plagued his life as it has the lives of his followers. A second chapter treats the buffalo. How the white man invaded the land of the Indians in search of the last of the buffaloes is pointedly portrayed.

Then there is an account of the early days of the cattle industry in the country of which someone then gibly wrote "that all the flocks and herds of the world could find ample pasturage on these unoccupied plains and the mountain slopes." The drought of 1885, followed by a great fire, killed thousands of cattle. The year '86 began with one of the worst blizzards of the Southern Plains, causing the death of cattle and sheep by tens of thousands. Even then, the good years and the lean were familiar.

Other chapters in the book tell of the settlers who followed the cattlemen. Home was a dugout—water and fuel always problems. Real estate promoters, railroads, and newspapers propagandized the new prairie. Drought began again in 1890; vast hordes of grasshoppers came two years later. It was the greatest "next year country" on earth.

There is an account of the work of J. E. Payne, of the Dry Land Experiment Station at Cheyenne Wells, Colorado, who gave sound advice to the settlers in the late 1890's. He minimized wheat. But a few years later people talked of a permanent change in the weather, and a land boom followed. Farmers thought "dust mulching" would solve their problems.

There was no better place for a rain-maker, and there is an account of the almost unbelievable efforts of C. W. Post, cereals magnate, to make it rain in the Great Plains by dynamite bombardment. But dust storms developed and broke the land boom in 1910. Then came World War I, and cries of "Plant More Wheat." By 1915 there was bumper crop. Nature worked for us when we needed it. With the war came efficient gas tractors, too, which replaced the steam juggernauts. High prices spread the wheat acreage. The combine appeared and further reduced the labor needed to harvest the crops. By 1920 there started a series of years described in a chapter called "The Great Plow-up."

By 1932 troubles developed. A late freeze; hail storms; cutworms; drought. The dust storms of 1933 and '34 are still vivid to most of us. They are covered by chapters significantly titled "Dust," "The Tired Land," ". . . And More Dust." The government gave emergency help. Dust Bowl refugees were common. Then folks met at Amarillo and asked for serious, careful analysis of land conditions in the Dust Bowl and for help in treating the land.

The book then relates the stirring story of how we tackled a great problem by democratic means. How tractors contour-listed five and a half million acres. Forty thousand farmers helped. A comprehensive program was inaugurated — of research, credit structure, state laws on tenancy, leasing, taxation, and land zoning, and of local organized action. It was a blueprint for rebuilding. More dry years and dust storms fought the plan. But the Soil Conservation Service gradually mapped the land and its capabilities. H. H. Finnell gets the credit for the soil-conserving and water-saving practices he advocates, and there is a chapter on Charlie Whitfield's remarkable methods of getting grass back on blown sand.

There is a brief account of President Roosevelt's shelterbelts, and his visit to Amarillo in 1938, when the rains came. During the next years, however, drought came again. But with the years of World War II there was rain once more, and bumper crops. The author calls his concluding chapter "Here We Go Again." He closes his book by the comment that in 1946 conservation practices were being abandoned here and there, and farmers claimed to be more aware of how to handle the land. The final words are: ". . . talk sounded to some as if it came from an old, old record being played again. The needle scratched."

Throughout the book Johnson has weaved an astonishing number of statistics—years, acreages, yields—so skillfully they seem to be parts of a fictional plot. Experiences of people of the Southern Plains are woven into the story, in some instances father and son, so that there is human as well as chronological continuity. A

great deal of careful study must have gone into the writing of this book. It strikes me as one of the best popular works on man and the land that we have had for some time.

—EDWARD H. GRAHAM

TWO BLADES OF GRASS. By T. Swann Harding. University of Oklahoma Press, Norman, Oklahoma. 352 pp., illus. $3.50. 1947.

MOST READERS of the JOURNAL of Soil and Water Conservation will find this book of interest, because somewhere in its pages a majority will find reference to the agency or agencies with which each is or has been associated in his professional work.

Labelled "a history of scientific development in the U. S. Department of Agriculture," the book confines itself to the research activities of this complex organization, including the related work of the state experiment stations and land grant colleges. These it covers with the characteristic thoroughness of such government compendiums as the Yearbooks of Agriculture, which it resembles in many ways.

The book grew out of an assignment given the author in 1933 when he was editor of scientific publications of the Department to survey and evaluate the monetary returns from research by Department scientists. After the formal report was presented, the project was continued and elaborated to appear as No. 2 in an Agricultural History Series issued by the Bureau of Agricultural Economics under the title, *Landmarks in the History of the Department of Agriculture.* Finally, it was rewritten for popular presentation and found a publisher in the University of Oklahoma Press.

This is a sustained tribute to the devoted and capable scientists who form the greatest agricultural research organization in the world. It re-emphasizes the major role of research in the work of the Department, a point which has been increasingly overshadowed by "action" and "regulatory" functions in recent years.

So many and so varied have been these research activities that to trace the major developments and mention representative examples has resulted in an account jam-packed with names, dates, and figures, with only the briefest exposition of any project. Necessarily, the style is condensed and personalities are submerged by facts, though credit is plainly given to the leaders in each field.

Thus, in the field of soil conservation, Dr. H. H. Bennett is labelled "our greatest militant soil evangelist of all time," and his work duly recognized. Yet, his career is reported in slightly more than one page of the text.

Some members of his organization, too, may be surprised to find the soil conservation program in the Department traced back more than 50 years, rather than to the erosion experiment stations of the '20s and the dust storms of the '30s. Farmers' Bulletin No. 20, published in 1894, is cited as the first Department publication on the subject, discussing effects of erosion and suggesting control measures. Bureau of Soils Bulletin No. 71, issued in 1911, also discussed the mechanism of the erosion process and possible control measures.

As to the results of the original survey which produced the book, Author Harding was duly impressed. The chapters are liberally sprinkled with $ signs comparing the costs of specific projects with the estimated benefits.

Without belittling the credits by one cipher, it can be pointed out that a strong tone of optimism runs through the report. To select an example from a field familiar to the reviewer, one finds on page 128, in a report on the results of range research by the Forest Service, the following: "In the end, methods were devised which would insure for the (livestock) industry the maximum nutritious and palatable forage consonant with a sustained or increasing crop. By accepting these methods, the livestock growers preserved their industry, increased their revenue, and came upon the secret of perpetual operation." The use of the past tense in the last sentence throws a peculiar light upon the growing efforts of both federal and state agencies to persuade stockmen that it would be profitable to do just these things.

However, there can be no gainsaying the author's conclusion, "that research performed by the Department of Agriculture scientists has been almost incredibly valuable to the American public, both in scientific advancement and in monetary terms." All will be grateful of this fine summary of the accomplishments of "those sincere, kindly, self-effacing, unavaricious humanitarians of highest integrity, the scientists who made the Department of Agriculture great as a research institution," to whom the book is dedicated.

—BEN OSBORN

SOIL CONSERVATION — AN INTERNATIONAL STUDY. By Mark Baldwin and others of the Agriculture Division, FAO. International Document Service, Columbia University Press, New York. 1948. 189 pp., illustrations. $2.00.

HERE IS A NEW 189-page book published by the Food and Agriculture Organization of the United Nations. It tells how soil erosion happens and how it can be checked. It gives the story of shifting cultivation, long used in tropical and subtropical lands, and how it can be improved to meet the needs of the people there and in other countries.

(*Continued on page* 100)

Recent Research Reviews

JAMES H. STALLINGS

THE REVIEWS by J. H. Stallings that follow are a regular feature in the JOURNAL. It is hoped that the projects reviewed from time to time will be helpful to conservationists everywhere. Members of the Society are urged to indicate their interest in the kind of research work that should be reviewed.

On the Hydrology of Culverts. *By* D. B. KRIMGOLD. *Proc. of the Twenty-Sixth Annual Meeting of the Highway Research Board, pp. 214-226, December 1946.*

Analysis of rainfall intensities and rates of runoff obtained from some 22 locations over several years not only did not produce the expected values, but gave support to those who doubted the validity of the rational method and of the rainfall runoff relationship. It was found that watershed characteristics and conditions of soils and of vegetal cover at the time of the storm are as important, if not more so, than rainfall amounts and intensities. Clearer understanding of the problem and information on soils, physiography and land use made possible delineation of areas in which results from the runoff studies are applicable. Through probability analysis of the runoff records, design curves were developed for several areas of application. Samples of such curves show variation of peak rates of runoff with soils, vegetal cover, as well as rainfall intensities and other climatic factors in various geographic locations. The shapes of the several curves express the relation of peak rates of runoff to size of drainage area in various physiographic provinces.

Results of Tests on Vegetated Waterways, and Method of Field Application. *By* MAURICE B. COX *and* VERNON J. PALMER. *Okla. Agr. Exp. Sta. Misc. Pub. No. MP-12, January 1948.*

This bulletin presents results of four years of research on the use of vegetation as a protective lining of farm waterways, such as pond spillways, terrace outlet channels, and natural watercourses. The protective ability and hydraulic characteristics of linings of alfalfa, Bermuda grass, blue grama grass, buffalo grass, weeping lovegrass, and a grass mixture native to Oklahoma were determined. The results are analyzed and presented in a manner such that engineers may apply them directly to the design of farm waterways.

Observations of Increased Moisture Penetration Under Combine Rows. *By* RANSFORD LEWIS, JR. *and* HERBERT A. HOPPER. *Northwest Science, Vol. 17, No. 4, pp. 95-98, November 1943.*

A study was made on Class I land on Brentwood loam in Siskiyou County, California to determine the effect of crop residue on moisture penetration into the soil. It was found that where surface and subsurface conditions were otherwise conducive to deep moisture penetration the use of a relatively light covering of crop residue as a surface mulch materially increased the amount, and therefore the depth, of moisture penetration. This finding supports, on a field basis in this area, the observations and findings of controlled research in other sections.

The Effects of Two Farming Systems on Erosion From Cropland. *By* GLENN D. BEDELL, HELMUT KOHNKE *and* R. B. HICKOK. *Soil Sci. Soc. of Am., Vol. 11, pp. 522-526, Proc. 1946.*

Runoff losses from fertile soils of the eastern part of the Corn Belt, where visible erosion is comparatively small, are reported. Runoff data include water, total solids, organic matter, nitrogen, organic and weak acid-soluble phosphorus, and exchangeable potassium. Data are given for comparable watersheds under a prevailing system of farming and under a conservation system.

The rainfall for the period reported was below normal for the locality. Runoff water losses from wheat and corn watersheds were similar under the prevailing treatment but were reduced by the conservation treatment with the result that substantial increases in water were available for crop growth. The water losses from land in meadow were small and not materially affected by treatment.

Nutrient losses under the prevailing treatment were found to be high in relation to the total solids eroded and high in comparison to the application rates of fertilizers. The conservation treatment greatly reduced the total nutrient losses in spite of increased rates of fertilizer application.

It is shown that the combination of increased fertilization and retention of water resulted in very substantial increases in crop yields.

While liberal fertilization and contour cultivation re-

duced water, soil, and nutrient losses by runoff and have increased crop yields on the watersheds at Lafayette, Ind., there are many conditions under which these practices may not be feasible or sufficient. Changes in land-use, terracing, strip cropping, mulch tillage, cover crops, and other conservation practices are needed in many places. The combination of contour seeding and cultivation, sufficient grass-legume meadow in the rotation, and liberal fertilization to increase crop growth and return of organic residues to the soil seem to be a sound recommendation for the eastern part of the Corn Belt land with moderately short and regular slopes not exceeding 5 per cent.

A Method of Estimating Sedimentation Accumulation in Stock Ponds. *By* L. C. GOTTSCHALK. *American Geophysical Union Transactions, Volume 28, Number 4, pp. 621-625, August 1947.*

By use of multiple correlation analysis to determine the function of the various factors related directly or indirectly to sedimentation in stock-water ponds a formula was developed for estimating sediment accumulation in ponds. Data obtained from detailed sedimentation surveys made of 18 representative ponds in central South Dakota served as the basis for this study.

It was concluded that the sediment accumulation in ponds, where drainage density was included, could be expressed best by the formula $s = 0.0077C + 0.0034 + 0.0015D - 0.0385$ where s is annual sediment accumulation in acre feet; C is capacity of the pond in acre feet; A is net drainage area in acres: and D is drainage density in feet per acre. This formula accounted for 91 percent of the variations in annual sediment accumulation as expressed by the standard deviation.

Where drainage density was not included it was concluded that $s = 0.0072C + 0.0003A + 0.0454$ was a better formula and accounted for 87 percent of the variance in sediment accumulation as expressed by the standard deviation.

Calculations for Land Gradation. *By* GRANT E. CHUGG. *Agr. Eng., Vol. 28, No. 10, pp. 461-463, October 1947.*

The author suggests and illustrates a procedure for obtaining field data to minimize office calculation time. By stadia or other means obtain approximate length and width of field. From this information and the topography determine the necessary equal distances for both width and length of field for a grid system layout. Then with the use of rod and level secure the required elevations of the field to be leveled.

Simple Pasture Management Practices Pay. *By* A. L. HAFENRICHTER. *Jour. Am. Soc. Agron., Vol. 40, No. 2, February 1948.*

The author finds that the length of the grazing season on Whatcom clay loam can be increased from an average of about two months to nearly six months by proper fertilization, the addition of appropriate perennial plants to the pasture mixture and supplemental irrigation.

Combined pasture management practices are better than any single practice. Fertilizer application, supplemental irrigation and rotation grazing—"the big three" of the pasture management practices—produced 85.9 percent more TDN per acre with an increase in value of $131.00 in milk, than the continuously grazed untreated pasture seeded to the same mixture and grown on the same site.

The Fundamentals of Mechanical Tree Planter Design and Performance. *By* H. D. BRUHN *and* F. B. TRENK. *Agr. Eng., Vol. 28, No. 9, pp. 387-390 and 396, September 1947.*

A tree planting unit built around a single-bottom, triangle-type tractor plow was designed and constructed in the latter part of 1943. The object was to handle the potential surplus of trees in the forest nursery of the Wisconsin Conservation Department. During the spring of 1944, 4,000,000 trees were planted by the 16 machines in operation during that time. The thorough test of mechanical tree planting over the past three years emphasized the line along which development should proceed and also many fundamentals of design and operation.

The authors give a brief description and summary of the design and performance of various elements of the planting mechanism.

The advent of the tree-planting machine has developed definite and favorable trends in forest development within the state. These trends embrace all classes of forest owners—individual, farm, estate and absentee owned, community, county and state.

Land-Use Practices on Runoff and Erosion From Agricultural Watersheds. *By* L. L. HARROLD. *Agr. Eng. Vol. 28, No. 12, pp. 563-566, December 1947.*

The author presents data from short-time studies from small watersheds showing the effects land-use practices have on runoff and soil loss.

It is tentatively concluded that improved practices, such as increased fertilizer and lime rates and use of

(Continued on page 102)

Field Notes and Comments

Farm Income and Soil Erosion Related to National Economy

When industry and soil conservation join forces, progress should be in leaps and bounds. Soil scientists and research workers can work together, each being a specialist in his own line and giving the necessary aid to the other. Economically speaking, they could share the same laboratories and equipment necessary to their research instead of having to buy their individual equipment.

A committee, known as the Business and Organization Relations Committee, has recently been set up by the Soil Conservation Society of America to weld agriculture and industry into an irresistible force against further deterioration of our resources. What we do today will be reflected in the yields of tomorrow and in the building up of a stable, prosperous, and peace-loving country.

Every industry, be it automobile, toothbrush, or shoe factories, has a stake in soil conservation and the maintenance of our agricultural program. Common sense tells us that it is good business to maintain a prosperous, growing agriculture.

When the land is productive and prosperous, the nation is prosperous because agriculture furnishes such a large percentage of the basic raw materials on which our industries depend. When a country is non-productive, it is reduced more and more to poverty. Industry cannot thrive on poverty.

Pointing out how dependent the prosperity cycle is upon the farm, H. A. Lyon, of the Staff of the Detroit Board of Commerce, the official sponsor of the "Prosperity from the Ground Up" movement, reports that in 1945 Michigan cherry growers lost about half of their crop by frost, and the apple growers of Michigan lost practically their entire crop. The loss has been estimated as high as $20,000,000.

"Had the farmers had that $20,000,000 income, they would have been able to purchase a very considerable quantity of the products of industry. Without it they could not. The ratio of farmer income to national income is about one to seven. Thus a $20,000,000 loss of income for the farmer cuts approximately $140,000,000 income from the national total. To us in the city, as well as to the farmer, this is a loss in terms of production and jobs," Lyons explains.

Such losses to society are peanuts compared to wealth which slips through our fingers in the form of soil and water losses.

Dr. H. H. Bennett stated in an address at one time that the cost of *NOT* going ahead with a scientific, acre-by-acre, soil conservation program during the next 20 years would probably amount to not less than $20,000,000,000 meaning the cost of inaction would average out at around a billion dollars a year. He went on to say that chances are the bill would run higher. It would be levied against us in terms of reduced yields, lost plant food, and reduced productive capacity, increased flood damage, increased damage to highways and railroads, increased silting of rivers and harbors, etc.

"Furthermore, always remember that those losses which permanently reduce productive capacity cannot be calculated. How can you place a proper value on a lost, productive capacity which would have produced commodities over many scores or hundreds of years?," Dr. Bennett concluded.

Let us consider another most important factor. Wealth cannot be had if the health of the nation is bad. Good lands provide good food and makes for healthier people. Healthy, strong people can work more efficiently, more diligently in the industries of the land.

—Warren C. Huff

Need for Conservation is World-Wide

Soil conservation no longer is a national problem. With our responsibility of helping to feed other nations, whose ability to look after themselves has been reduced by war and post war developments, it becomes clear that we cannot continue to export tremendous amounts of agricultural products indefinitely without endangering the fertility of our soils. On the other hand we can only expect to export industrial products to nations that have a prosperous farming population. Paupers are no good customers. The world's population has rapidly increased in the last 100 years and with it the need for food. With the development of ever more efficient agricultural implements the exhaustion and erosion of soils has increased rapidly.

This country has probably the dubious distinction of having converted broad rich acres into eroded worn-out land faster than any other land. On the other hand there has been more done about righting this wrong in

the United States than anywhere else. This goes both for research and for actual improvement work in the field.

It is high time that the peoples of this ever shrinking world get together and attack with united effort this problem of soil conservation and maintenance of food production. I visited Western Canada last summer and have had discussions with students from India and it is very clear to me that those countries—just to mention examples—are seriously in need of soil conservation work. They need research of their own, but they need close contact with other countries to get more information, and they have information to give to other countries.

All this makes it very obvious that some international medium should be created for exchange and dissemination of soil conservation knowledge. A beginning has been made by inviting trainees from other lands to learn soil conservation methods in this country. That is fine, but not enough. We need a more general exchange of students, technicians and professors. We need an international bulletin of soil conservation to which soil conservationists from all over the world would contribute. We need international meetings of soil conservationists, where not only the technical questions concerning soils, crops, forestry, engineering, economics, biology, etc. would be discussed but where also matters such as soil conservation, philosophy, education and legislation would receive attention. These meetings should be non-political as far as that is possible. The right to attend should not be denied or abridged to anyone on account of race, color or previous or present condition of political affiliation.

—HELMUTH KOHNKE

Inter-American Conservation Conference

The Department of State announced today that the First Inter-American Conference on the Conservation of Renewable Natural Resources is scheduled to be held at Denver, Colorado, from September 7 to 20, 1948. After many other sites had been considered, the Governing Board of the Pan American Union and the Department of State decided to hold the Conference at Denver. The presence of many conservation projects in the surrounding territory was one of the factors contributing to the selection of Denver as the site. The Conference is being held pursuant to a resolution adopted at the Third Inter-American Conference on Agriculture held at Caracas, Venezuela, in July 1945.

The Conservation Conference, the first international meeting of its kind, will bring together Delegates from the American Republics to consider the development and use on a sound scientific basis, of the renewable natural resources of the Hemisphere. It is anticipated that leading Government officials, scientists, and other interested groups from the entire Hemisphere will attend.

Among the problems to be discussed will be those arising out of deforestation, soil erosion, overgrazing, wildlife destruction, floods, and failing water supplies. These problems are yearly growing more serious throughout the Hemisphere because of inadequate conservation practices, mounting populations, and attempts to raise living standards. They are of world-wide significance because of the increasing needs of Europe and Asia.

The Conference will consist of a series of meetings to discuss conservation problems together with field trips to study land management practices. The Delegates will have an opportunity to view at first hand soil conservation districts, forest and range experiment stations, the Rocky Mountain National Park, and other places of interest. Irrigation projects will be studied, along with their relationship to agriculture, grazing, and forestry

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practices on the land from which irrigation waters are derived.

Warren Kelchner, Chief of the Division of International Conferences, Department of State, has been appointed Executive Vice President of the Conference, and William Vogt, Chief of the Conservation Section of the Pan American Union, Secretary General. An Organizing Committee composed of representatives of interested government agencies has been established to formulate plans and coordinate arrangements for the Conference.

Progress of Soil Science Slow

The progress of soil science in the United States has been slow compared with that of other sciences, partly because of the belated recognition of soil problems by people generally. Future progress is limited by lack of fundamental data.

Although research work in soils must proceed along several lines, it is impossible to overemphasize the necessity of having its many phases closely coordinated. One of the principal reasons for the meager progress to date is the piecemeal fashion in which much of the work has been conducted.

The study of soils to obtain information for determining their best use should proceed along the following four general lines more or less concurrently, since advancements in one field lead to suggestions for improvements in the others:

1. Land inventory of physical conditions.
2. Determination of the morphological, physical, chemical, and biological characteristics of soils.
3. Determination of the responsiveness of soils to management, including tillage, fertilization, conservation crop rotation, and water control; terracing and other erosion control devices; drainage and irrigation.
4. Determination of soil capabilities on the basis of physical data and experience.

A land inventory is essential to the soil-research program and to the practical application of the findings of such research. Primarily the inventory serves as a basis for classifying the results of experience and experimentation regarding the characteristics and capabilities of soils so that these results may be applied to individual farms and ranches.

To understand the basic soil properties that are important to the growth of plants, the physical, chemical, and biological make-up must be determined. These studies may be grouped conveniently under four principal heads: morphological studies in the field and physical, chemical and micro-biological studies in the laboratory.

Morphological field studies include the determination of the depth, structure, and other visible characteristics of the several layers which make up the soil in which the plant roots develop and from which the plant obtains its nourishment.

Although progress in chemical investigations has been rapid during the past 10 years, determination of the amounts of the various nutrients available to plants in the soils is still urgently needed.

Present knowledge regarding the chemical nature of the soil is inadequate; many lines of work must be developed in order to obtain needed data. The chemical analyses must be supplemented by controlled experiments with growing plants to establish the relationships between the nature of the soil and the ability of the plant to obtain from it the materials needed for normal functioning and growth. The most pressing needs are:

1. Chemical analyses showing total composition and available nutrients. These are lacking for many important soils. Studies of the content of minor soil elements and their influence on plant nutrition should be included. We need to perfect a method for determining available phosphorus in western areas which are high in lime.

2. Reliable methods for determining the fertilizer needs of arable soils through "quick tests". These are urgently needed.

3. Mineralogical analyses of soils and other research to discover the compounds responsible for "fixation" of fertilizers in the soils, the degree to which fertilizers are "fixed," and ways whereby undesirable fixation, which makes nutrients unavailable for plant use, may be overcome. This problem is particularly important with many of the soils needing phosphates which frequently are fixed so quickly and firmly as to be useless to plants.

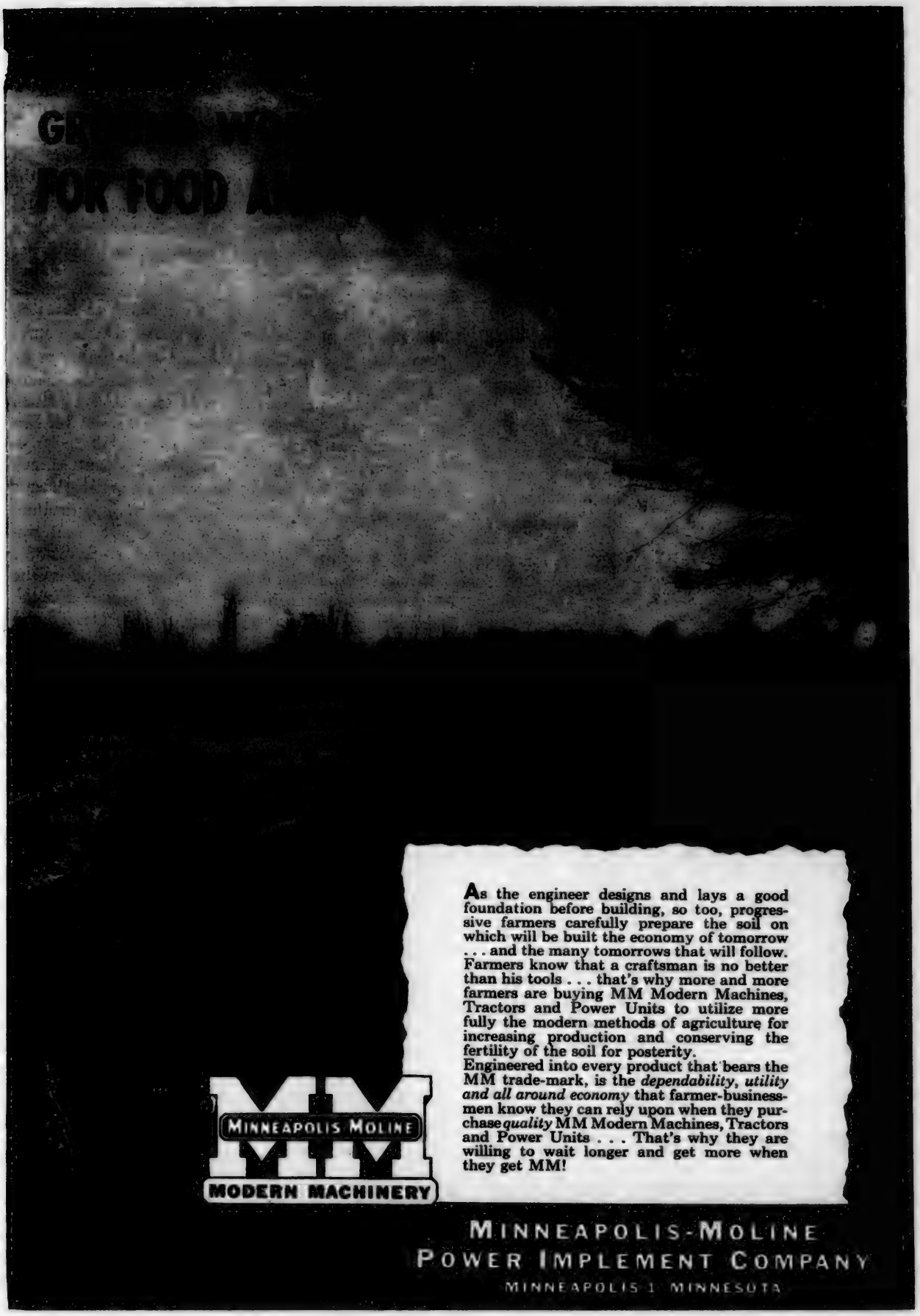
4. More precise information regarding the physical and chemical changes in arable soils as a result of use. Important, but largely unknown, changes are brought about by the crop plants themselves and through tillage, fertilization and erosion.

5. Research to find the relationship between the nature of the soil and the quality of the food it produces.

Findings of significance regarding soil organisms have been made, especially in regard to organisms associated with legumes and otherwise of importance in nitrogen nutrition.

That farmers may plan their operations to the best advantage, knowledge must be available regarding the capabilities of the soils on each farm. The largest part of this information is gained from the farmer, observation and field trials.

—R. M. MARSHALL



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Code of Agricultural Ethics

(*Continued from page 60*)

residues which should return to the soil as organic material.

A good agriculturist will appreciate that man has a place in the animal kingdom that he will only succeed in holding if he does his part in helping to maintain a balance in nature. If man fails to find and accept his place in the scheme of things, he will surely bring about his own destruction.

A good agriculturist will keep himself informed on the latest research developments in his own field as well as to re-explore the old. He will exert individual leadership as well as cooperate in the community effort of his fellowman. Universal recognition and acceptance of this individual responsibility, coupled with a willingness to cooperate, will cure most of the social, economic and spiritual ills that at present beset our agricultural state.

Lastly, a good agriculturist accepting these responsibilities can insure to posterity an inexhaustible resource of rich and productive soil. In so doing he can assume his rightful place in the honorable and indispensable professions that serve all mankind.

—DR. M. M. HARGRAVES,
Mayo Clinic, Rochester, Minnesota

Soil and Nutritional Troubles

(*Continued from page 68*)

(8) McClendon, J. F.
1939. Iodine and the incidence of goiter. Univ. of Minn. Press. Minneapolis. 126 pp.

(9) Mitchell, J. H.
1941. Sources and distribution of iodine in South Carolina with special reference to types of soil and rocks. Soil Sci. 52: 365-371.

(10) Ross, W. H., Rader, L. F., Jr., and Beeson, K. C.
1938. Citrate-insoluble phosphoric acid in ammoniated mixtures containing dolomite. Jour. Assoc. Official Agr. Chem. 21: 258-268.

Research Needs of Tillage

(*Continued from page 104*)

The agronomist, to find the crop rotation and soil management practices to maintain soil fertility and soil structure favorable for maximum crop yields. The entomologists, to develop sprays to control the insects and weeds. The engineer and implement manufacturer, to design and build tillage and spray machines. The animal husbandryman, to determine the livestock program to best utilize the crops produced. And last but not least, the economist, to help plan for the greatest returns with the long-time over-all objective, the maintenance of the soil—our most valuable natural resource.

Book Reviews

(*Continued from page 93*)

The broader principles of conservation outlined in this most interesting book can be applied anywhere, but the method and practice of their application require careful study by specialists in any country intending to start a soil conservation program. To enable these specialists to take advantage of the experience on soil erosion problems already gained by others, the book discusses at length the work done in China and the United States of America, as well as in other countries. Together these countries provide examples of land use and abuse under many combinations of physical, social and economic conditions.

The book states that the need for soil conservation programs exists in most countries of the world. It also points out that it is not necessary to establish a specialized agency to develop these programs. Countries may approach the problem by staffing the various departments of the national ministry or department of agriculture with specialists in various fields who view soil conservation as one of the objectives within their own field.

Senior author of this book is Mark Baldwin of the Agriculture Division of FAO. Other contributors in the Agriculture Division are J. Lossing Buck, Head, Land Use Branch; Herbert Greene; A. B. Lewis; and T. C. Tsiang. S. B. Snow, Chief, Forestry Branch, of the FAO Forestry and Forest Products Division contributed material on forest and range lands.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933

Of JOURNAL OF SOIL AND WATER CONSERVATION published quarterly at Baltimore, Maryland, for March 1948.

State of Maryland, Baltimore City, SS.

Before me, a Notary in and for the State and county aforesaid, personally appeared John Henry Ferguson, 4th, who, having been duly sworn according to law, deposes and says that he is the Publisher of the JOURNAL OF SOIL AND WATER CONSERVATION and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Soil Conservation Society of America, Box 1409, Spartanburg, S. C.

Editor, Walter C. Gumbel, Bethlehem Bldg., Fairmont, W. Va.

Business Manager, Wiley B. Hampton, Box 1409, Spartanburg, S. C.

2. That the owner is: Soil Conservation Society of America, Inc. (No stock issued.)

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

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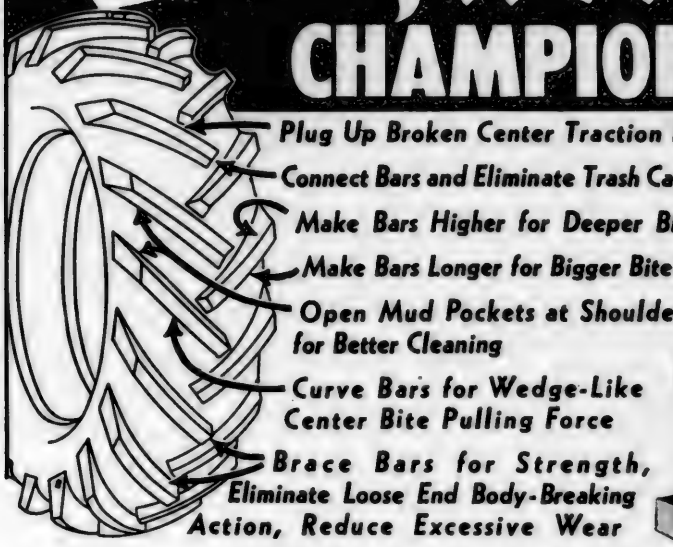
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Recent Research Reviews

(*Continued from page 95*)

alfalfa in the rotation, have not had a material effect on water conservation for the period studied, on areas having the poorer drained subsoils. Good sod crops furnish excellent protection to the ground surface, thus preventing raindrops from puddling and sealing the soil surface and enabling the soil to absorb more water. Contour cultivation of corn has not yet been effective in conserving water for storms over one inch in amount. Mulch culture for corn provides an effective means of protecting the soil surface from sealing under the impact of raindrops, and enables the soil to absorb larger quantities of water. Strip-cropping is not so much a "water saver" as it is a "soil-loss retarder."

Erosion and Production Under Missouri Grazing Systems. *By* D. M. WHITT *and* D. D. SMITH. *Soil Sci. Soc. of Am. Proc., Vol. 12, 1947.*

The authors report the results of seven years on five pastures on Putnam silt loam soil. Five grain systems are also included for comparative purposes.

These studies point conclusively to the fact that good pastures are a powerful tool in controlling erosion. Only one system under measurement, barley and soybeans, exceeds three tons of soil loss per acre per year even with the rows up and down the slope on a 90-foot plot. These plots, as well as the crop sequence plots on the farm show that one of the major causes of soil loss is the number and length of periods when the ground is without cover. With the pasture systems studied thus far such periods are reduced to a minum or eliminated altogether.

Timothy with lespedeza, as well as the same crops supplemented by sweet clover averaged less than one-half ton of soil loss per acre per year. The latter combination on the average retained two inches more water per year than where sweet clover was omitted.

Wheat lespedeza grazed produced the highest yield of beef. The average was 261 pounds of beef per acre per year. Timothy—sweet clover—lespedeza averaged 241 pounds of beef per acre annually.

Wheat and lespedeza harvested for grain and hay was the highest producer in terms of net returns. Timothy and lespedeza grazed was a close second, while three bluegrass pastures were the lowest producers.

Rates of Runoff for the Design of Conservation Structures in the High Plains of Colorado and New Mexico. *By* HAYDEN K. ROUSE. *To be published as USDA.SCS-TP.*

This publication is one of a series containing information for the design of spillways, diversions, culverts, terrace outlets, and other structures where peak rates of runoff govern design. In it, an attempt has been made to utilize all available pertinent information to the end that data in usable form be available for use in soil and water conservation and other activities requiring information on maximum rates of runoff.

Trees and Tree Planting for Posts, Windbreaks and Erosion Control. *By* M. AFANASIER. *Okla. Agr. Exp. Sta. Tech. Bul. No. T-29.*

Several hundred windbreak and post-lot plantings scattered over the State of Oklahoma were studied with the view of determining the factors most conducive to successful handling of such plantings.

This bulletin summarizes the facts about selection of species, planting method, and after-care as shown by study of both successful and unsuccessful plantings. It was concluded that survival of trees can be greatly increased by choosing the right species for the location, planting the trees properly, and giving them good care for the first few years after planting.

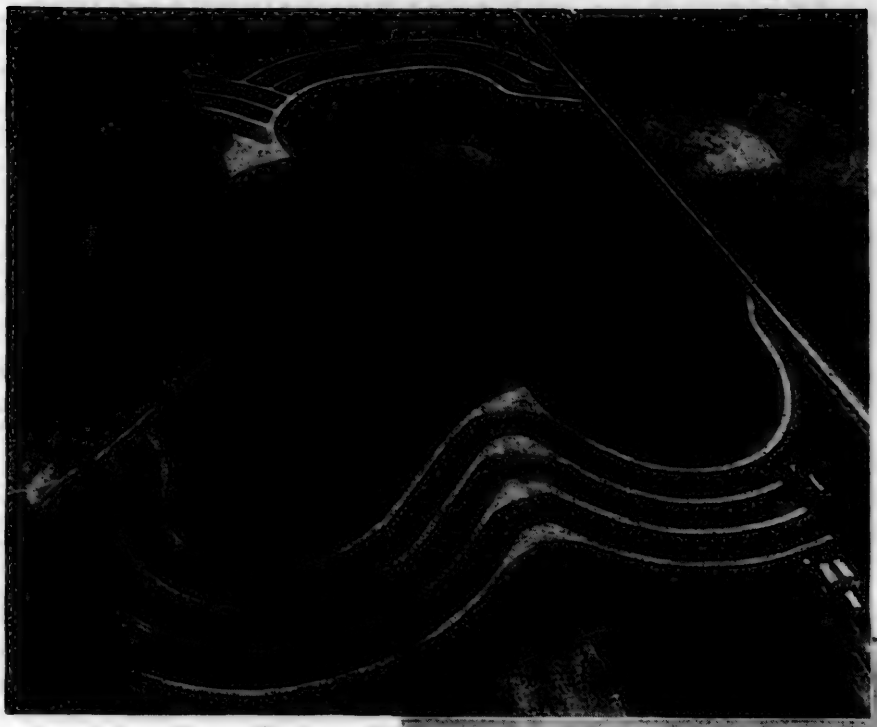
Conservation Work in Nurseries

(*Continued from page 89*)

tion of woody planting nursery stock. This has been done for the Florist industry and for the truck-crop industry to a great extent but little has been done on the production of nursery stock. I realize that this is not the job of Soil Conservation Service but this work must be done by some agency so that the conservationist can accurately plan and advise the nurserymen in his production problems. This same problem exists in the use of proper soil building and cover crops. This is especially true for the South.

I have been told that there is need for one-half billion more seedling trees this year for farm and other soil conserving plantings. The nurseries can produce these seedlings if and when asked. The American Association of Nurserymen policy in regard to tax supported nurseries and free distribution of nursery stock is that we support the production of nursery stock for distribution for the purpose of reforestation and timber production on publicly owned lands. We are opposed to the production of nursery stock for the purposes other than reforestation and timber production on privately owned lands in the belief that reforestation of publicly owned lands is the proper function of federal or state governments. The distribution of nursery stock for any purposes on privately owned lands is a proper market for the privately owned nurseries.

IT'S A MATTER OF *principle...*



Increased yields averaging 20% or more were reported in a recent survey of farmers using conservation farming methods. One of the basic practices on most of these farms was contouring. Based on the principle of working on the level—around hills rather than up and down—contour farming holds water where it falls, stops soil erosion and "levels out" power requirements.

High compression combines more power with the greater convenience features of gasoline through use of this engineering principle: Each additional pound per square inch of compression pressure before ignition gives approximately *four* additional pounds per square inch of pressure on the power stroke after ignition. Result: High compression gasoline engines mean more power *plus* more convenience.

SOUND PRINCIPLES PAY OFF ON THE FARM

Just as contour farming has proved to be easier as well as more productive, high compression tractors have also demonstrated many extra advantages in addition to turning out more power on less fuel. They are easier to start, cleaner to operate and more dependable on the job. As a result, there are more high compression gasoline tractors than any other type at work on farms today.

As a matter of principle– RECOMMEND HIGH COMPRESSION TRACTORS

ETHYL CORPORATION, *Agricultural Division,* Chrysler Building, New York 17, N. Y.
Manufacturer of antiknock fluid used by oil companies to improve gasoline.

Research Needs of Tillage

(*Continued from page 78*)

machines and can be expected to break down soil structure more than any other machine in action. Work by Yoder and Page at the Ohio Station emphasizes this point. Seedbeds that were prepared by this machine silted and crusted over during the first rain, were not favorable to plant growth and would have presented a serious erosion problem if the land had been sloping.

Cultivating Equipment

What about cultivating equipment? So far we have discussed implements for seedbed preparation. Cultivation is an important part of crop production; therefore, a paper on tillage would not be complete without considering briefly cultivating equipment. Experiments show that we cultivate to kill weeds, not to build structure. This is especially true where soil structure has been maintained by proper soil management practices. Research has shown that soil tilth deteriorates from erosion and by intensive farming to intertilled crops. Hard driving rains seal and crust the surface. Air and water cannot enter the soil as it should for optimum root development and maximum crop growth. Cultivation helps areate the soil and temporarily improves the structure. Of course cultivation under these conditions is only a means to an end. It does not really solve the problem of soil structure. We should re-emphasize that tillage is an important tool to the maintenance of soil structure. However, tillage has its greatest effect on soil structure when used to supplement rotations that contain plenty of grasses and legumes to supply organic matter—the key to improving soil fertility and soil structure. When this is done, and present cropping systems are a long ways from that, then the main value of cultivation will be to control weeds.

Are the present cultivating tools suitable for handling row crops on the contour? The question in the minds of farmers of the difficulty in controlling weeds with present cultivating equipment on contoured row crops has more than anything else delayed adoption of this simple but effective conservation practice. This is mainly a mental hazard, although there are reasons to believe this. Present cultivating machines are not flexible enough. We may adjust a machine to do a good job of cultivating and weed control in one direction around the hillside. On the return trip the machine is out of adjustment. Plants may actually be plowed out and the weeds remain uncontrolled. There is need for developing separate controls on two-row cultivators. The use of sweeps instead of shovels, greater speed in cultivation, the use of the disk hiller are all practices that need to be more fully developed and adopted by farmers. Progress has been made along these lines but much remains to be done. This is a very important field in which immediate work and development will help contour farming to be adopted on more acres in this country.

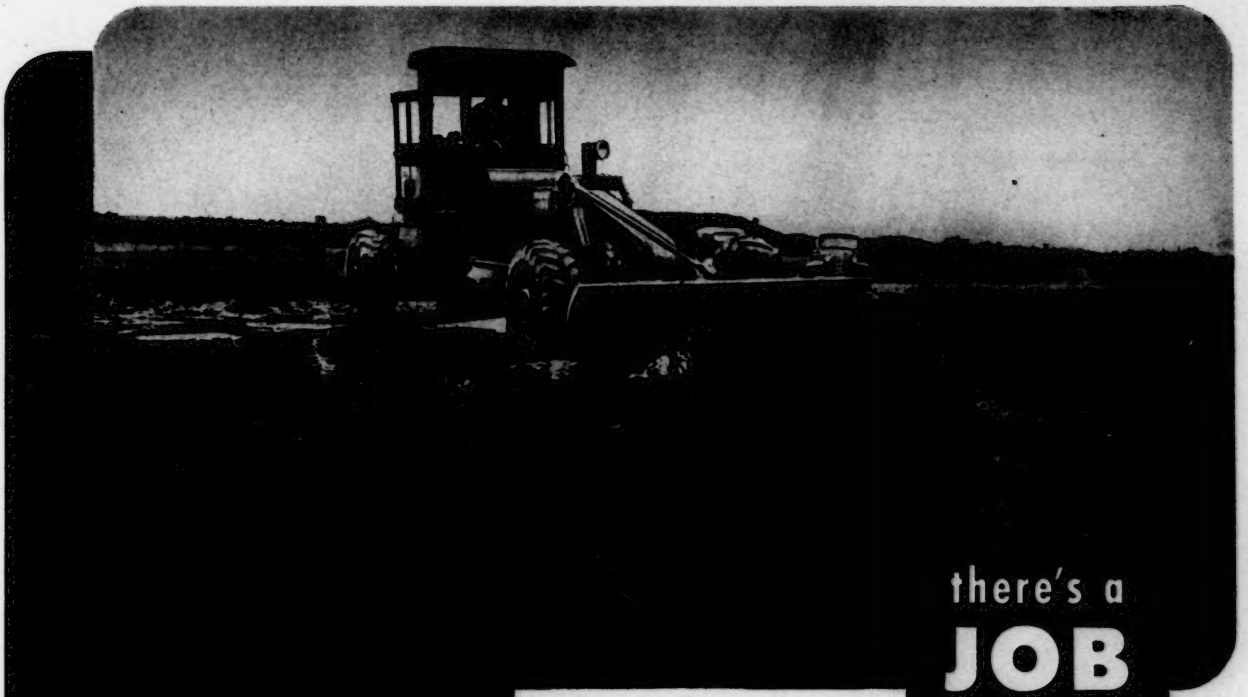
More Research Is Needed

In addition to our common crops the tillage problems of less extensively grown crops, such as potatoes, needs to be considered. Engineers of the Department of Agriculture and the Agricultural Experiment Stations have made much progress in solving these problems. However, additional research is needed.

Much progress has been made in developing sprays selective for certain crops and weeds. Further developments along this line may completely revolutionize present tillage practices. The meadow in the rotation is in itself one of our most effective weed-control measures. If enough meadow is included in the rotation to maintain favorable air-water and nutrient relationship, the need to till the soil and cultivate intertilled crops to improve soil tilth and control weeds is largely eliminated. Under these conditions we may even visualize a single machine to prepare the seedbed and plant the crop in a single operation. The crop residue would be on the surface to protect the soil from erosion. The surface would be left rough to impound water providing for optimum use of the rainfall. Sprays would control the weeds. The next operation would be harvesting the crop. This would reduce the cost of producing a crop and at the same time avoid the destructive effect of tillage practices on soil structure. I don't believe that this is wishful thinking. It is a real possibility. It is a challenge to cooperation between several fields of interest.

(*Continued on page 100*)

Figure 2. Preparing seedbed for corn with subsurface tillage machine. Large sweeps operate under the surface, loosening the soil without inverting it. The residues are left on the surface to protect the soil from beating action of raindrops.



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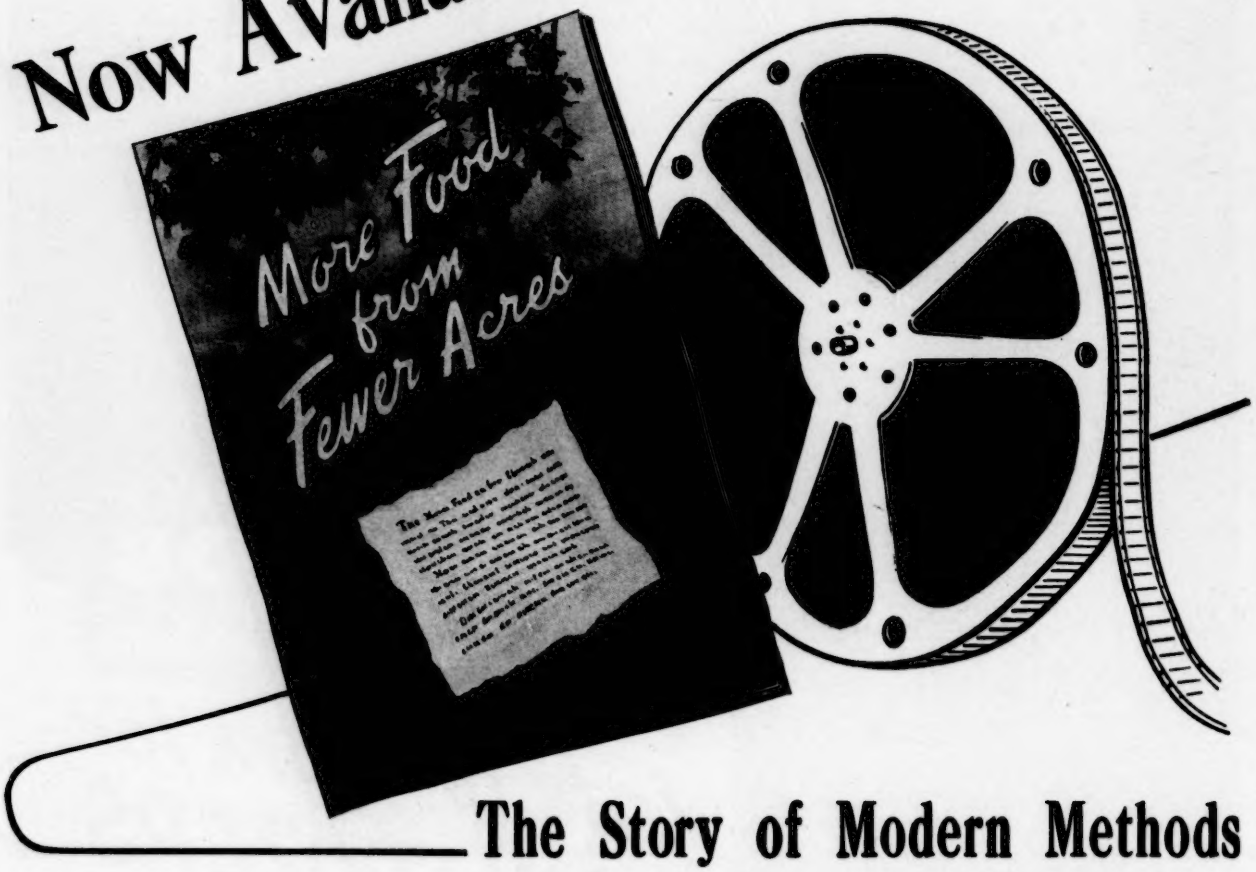

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